THE

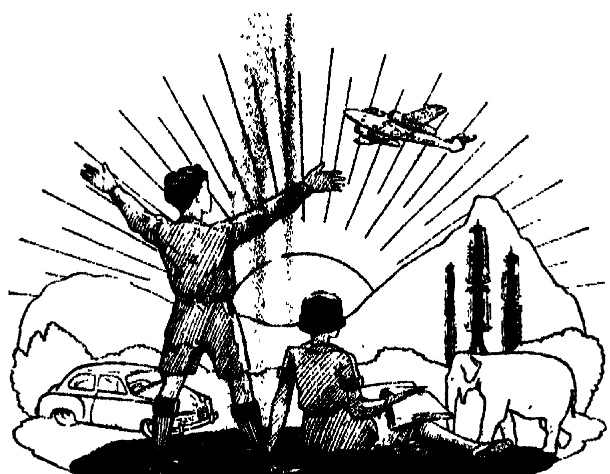
WORLD OF WONDER

10,000 THINGS

Every Child Should Know

Edited by

CHARLES RAY



VOLUME THREE

Pages 737—1096

London

THE EDUCATIONAL BOOK CO. LTD.

Tallis House, Whitefriars

MARVELS of MACHINERY

HOW A PLANE SMOOTHS THE WOOD

The plane is an exceedingly useful tool, and it is worth while to know how it is that the sharp edge of the plane iron can make the wood smooth. We could not, of course, smooth a plank satisfactorily merely with a sharp knife blade. On this page is explained the way the plane works and the great variety of planes that are used for special purposes

PROBABLY not many people who use a plane ever wonder exactly how it is that the plane makes the wood smooth. Of course, we know in a general way that the sharp edge of the blade, or plane iron, as it is called, cuts away the wood. But there is something more than this about planing, and the picture on the opposite page explains exactly how the wood is cut.

To get over this difficulty a large stock is used, which rides over the roughnesses and removes successive shavings from the more projecting parts until they are all worked down to the level of the deepest depression When this has been done a continuous shaving can be taken by the carpenter neatly and easily from the whole length of the piece of wood.

Of course, the resulting degree of flatness depends to a large extent upon the skill of the workman.

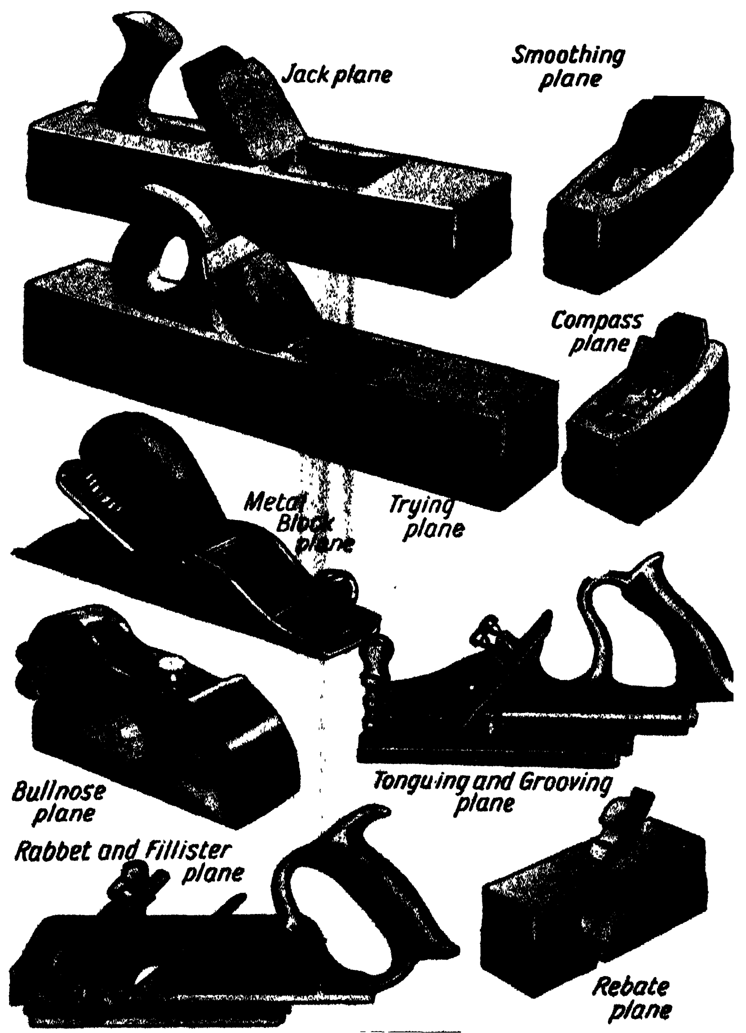
In using the tool a carpenter moves the plane as though he were trying to hollow the timber slightly, in that way insuring that he shaves equally along the whole length. With a long stock it is impossible actually to hollow out any part of the wood.

There are many different kinds of planes suited to different types of work, and some of the chief of these are shown in the picture on this page. The best known are the jack plane and the smoothing plane. The stock, or body of the plane, is generally made of beechwood, and the cutter or plane iron is inserted through an aperture, with the cutting edge projecting slightly at the bottom of the stock, at what is known as the mouth of the plane.

The Work of the Iron

On being pushed over the surface of a piece of wood, the plane iron acts like a chisel and cuts into the wood, removing it in thin pieces known as shavings. The pressure on the blade would drive it up, only it is held in position by a wedge, though in some cases a screw is used.

For the roughest kind of planing where the wood has a very unequal surface, a large jack plane is used, and it is worth while knowing why, for this purpose, the large plane is required. It is necessary, of course, that the cutter or plane iron should act only upon the projecting portions of the wood, but if a small tool were used the plane would go up and down over these inequalities and, in this way, fail to make a level surface.



Nine different kinds of planes in general use. The jack, trying, smoothing, and metal block planes are for smoothing ordinary work; the compass plane is for curved surfaces, the bullnose, tonguing and grooving, rabbet and fillister, and rebate planes are for cutting tongues, grooves and slots. Rabbet and rebate are alternative terms

A trying plane is very much like a jack plane, except that it is rather longer and has a closed handle like that of a saw Its office is to correct the inequalities left by the jack plane.

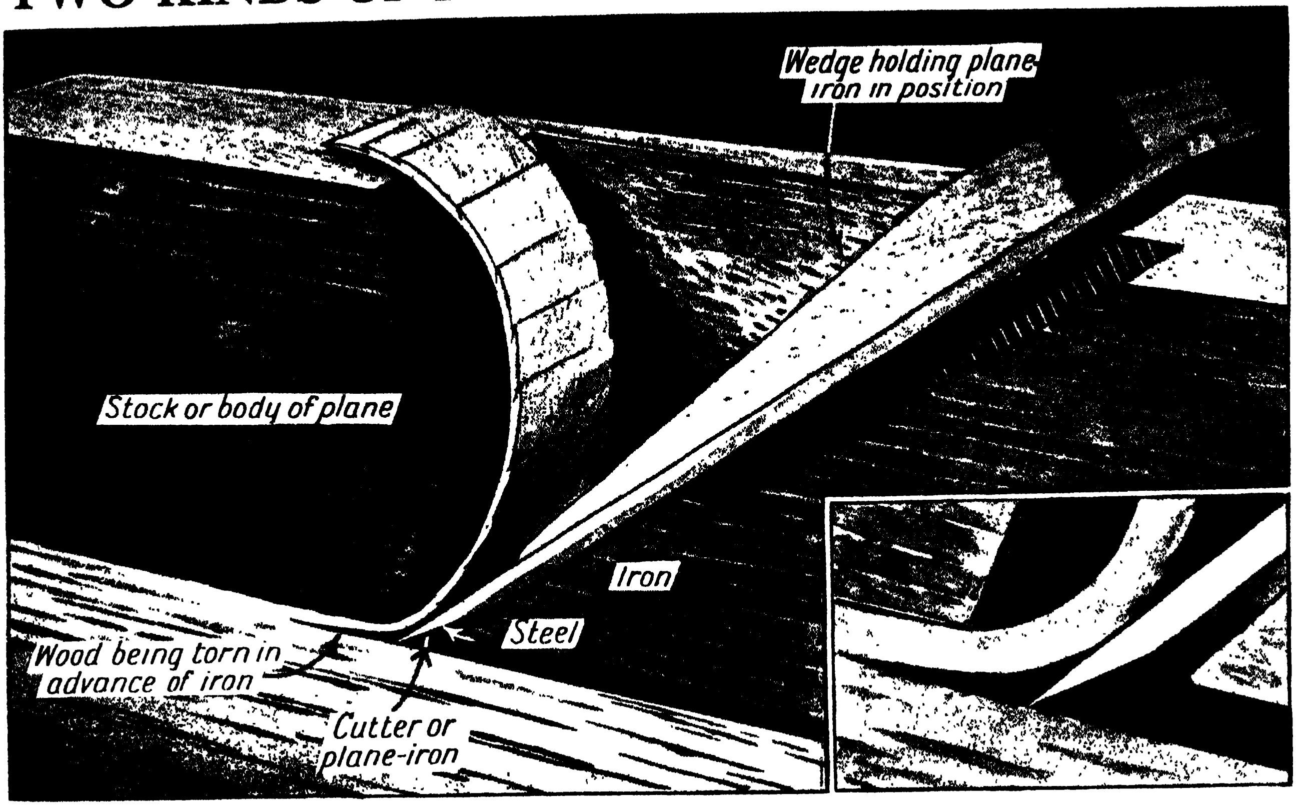
The smoothing plane is much shorter, and its work, as its name suggests, is to smooth or finish a surface It is usually about eight inches long, whereas a trying plane is about two feet, and a jack plane about eighteen inches

For Special Work

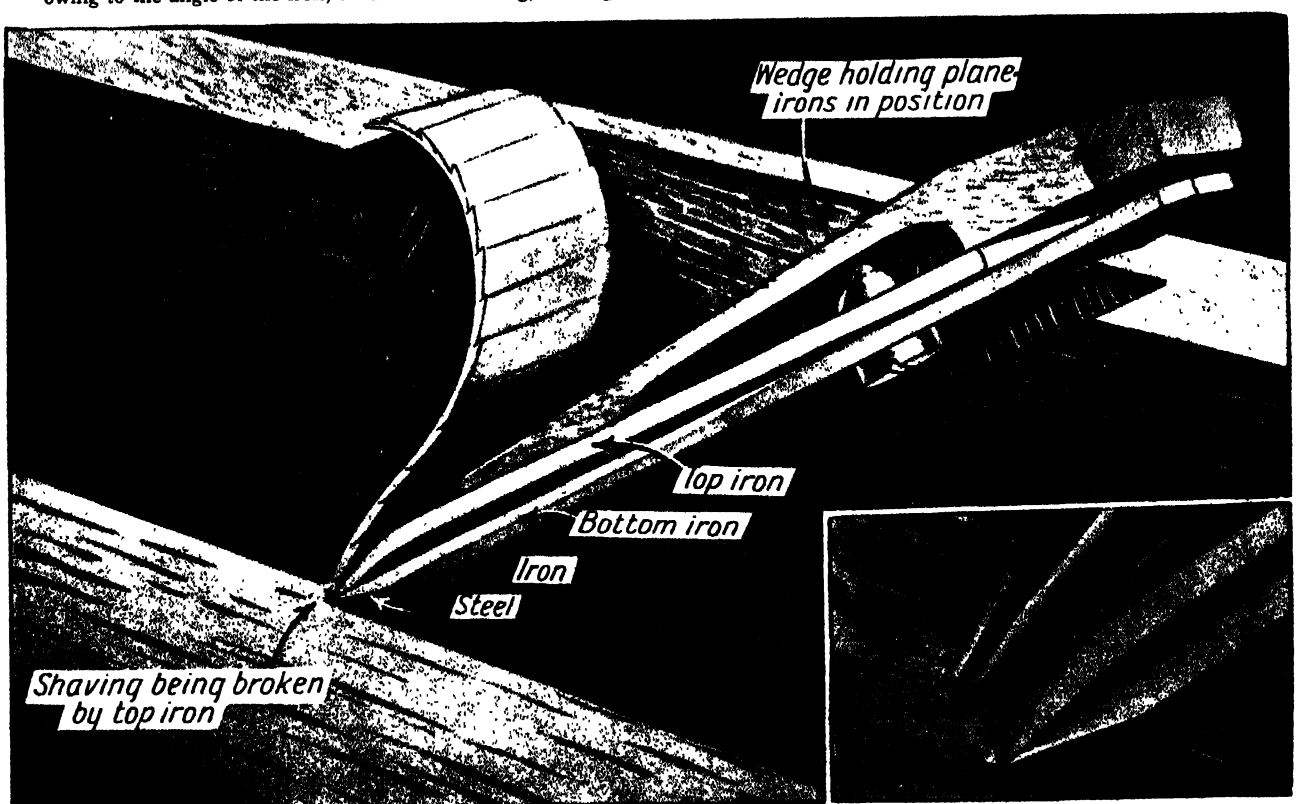
For planing hollow or round surfaces the stock is usually curved, and the tool is known as a compass or round sole plane. There are all sorts of special planes for doing particular work, such as fillister and plough planes for planing grooves or slots along the edge or face of a piece of wood. Other planes of this type are the grooving plane, the tonguing plane, the bead plane, and the ovolo or moulding plane. In the old days of hand work all moulding had to be done by means of planes, but nowadays wood-moulding machinery has largely superseded planes for the cheaper types of work.

Planes may have single or double irons, and the operation of these is clearly shown in the picture diagram on page 738.

TWO KINDS OF PLANE AND HOW THEY WORK

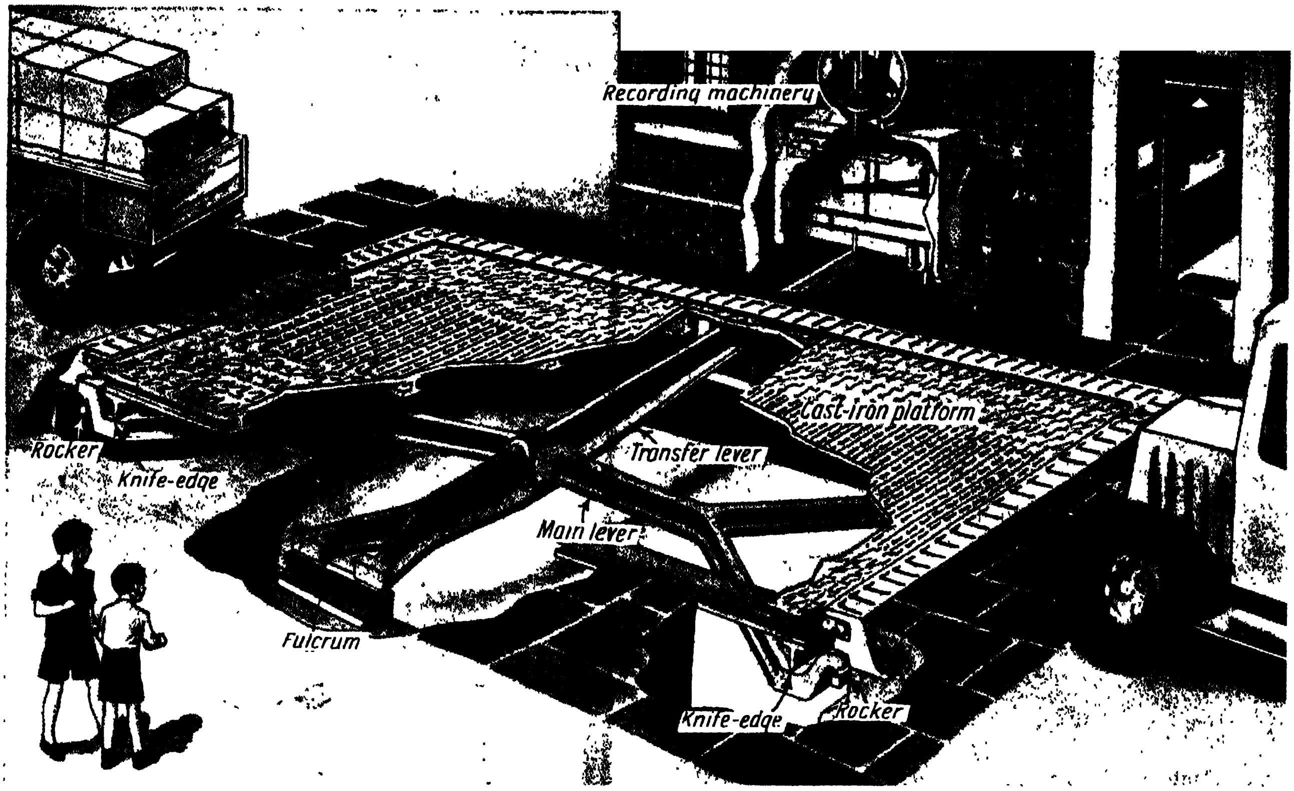


A plane smooths the wood because the steel edge of its cutter or plane-iron shaves off the inequalities of the rough surface. In this picture we see how a plane with a single plane-iron, while shaving the wood, is liable to tear or split it in front of the shaving, because owing to the angle of the iron, it raises the shaving, causing the tear in front. The small picture shows this on a larger scale

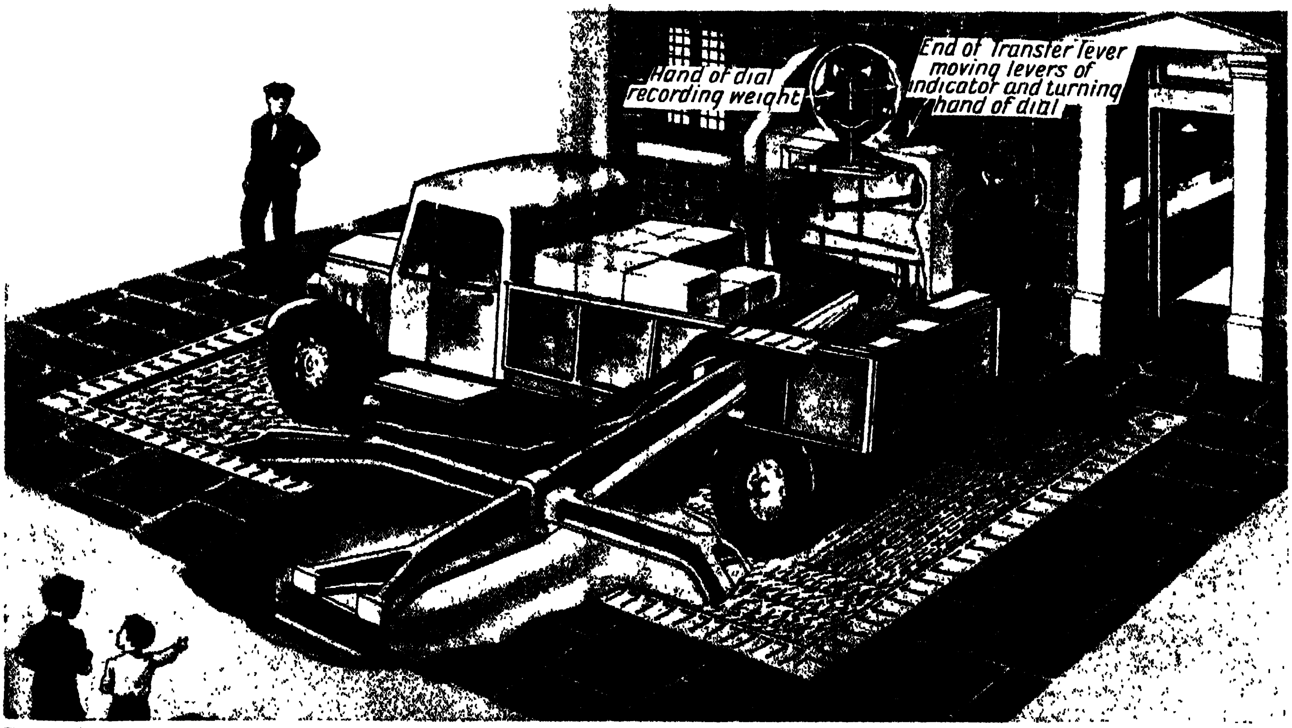


To get over the difficulty of the tear in front of the shaving, planes are fitted with double irons, as shown here. The top iron takes no part in the cutting, but by pushing up the shaving and breaking it as the plane moves forward, it avoids the tear in front

HOW A HEAVY VEHICLE IS WEIGHED

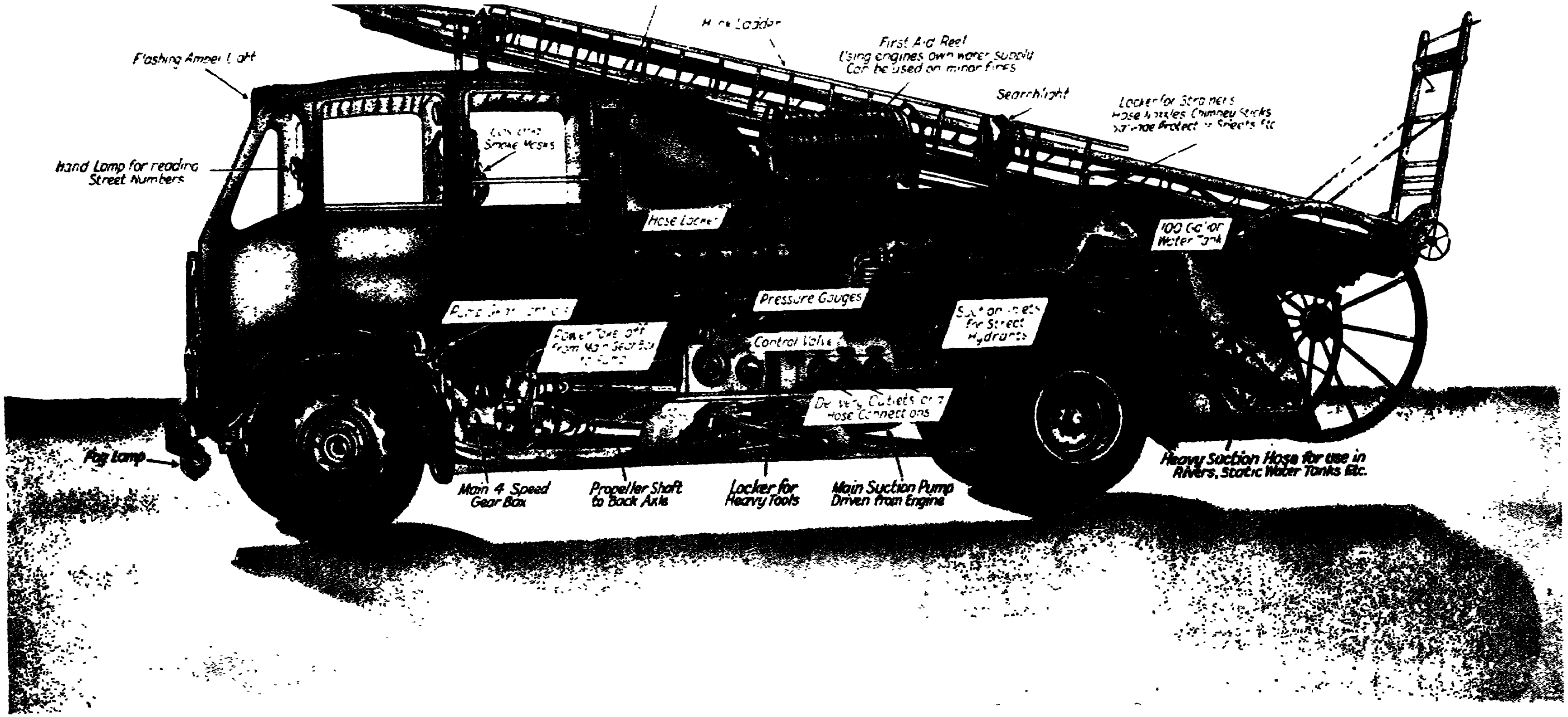


In this picture we see a weigh-bridge with the platform cut away to show the mechanism underneath. The platform stands on steel joists, which rest on a steel bar with a V-shaped lever at each end. To avoid friction the parts in contact are knife-edges of hard steel, and these rest on rockers. When the vehicle goes upon the platform its weight is transmitted by the V-shaped levers to a transfer lever connected with the recording machinery in the office, and operates a series of levers there, the weight of the vehicle and its load being automatically recorded on a dial. This type of weigh-bridge, made by Messrs. W. & T. Avery, Ltd., is quite foolproof



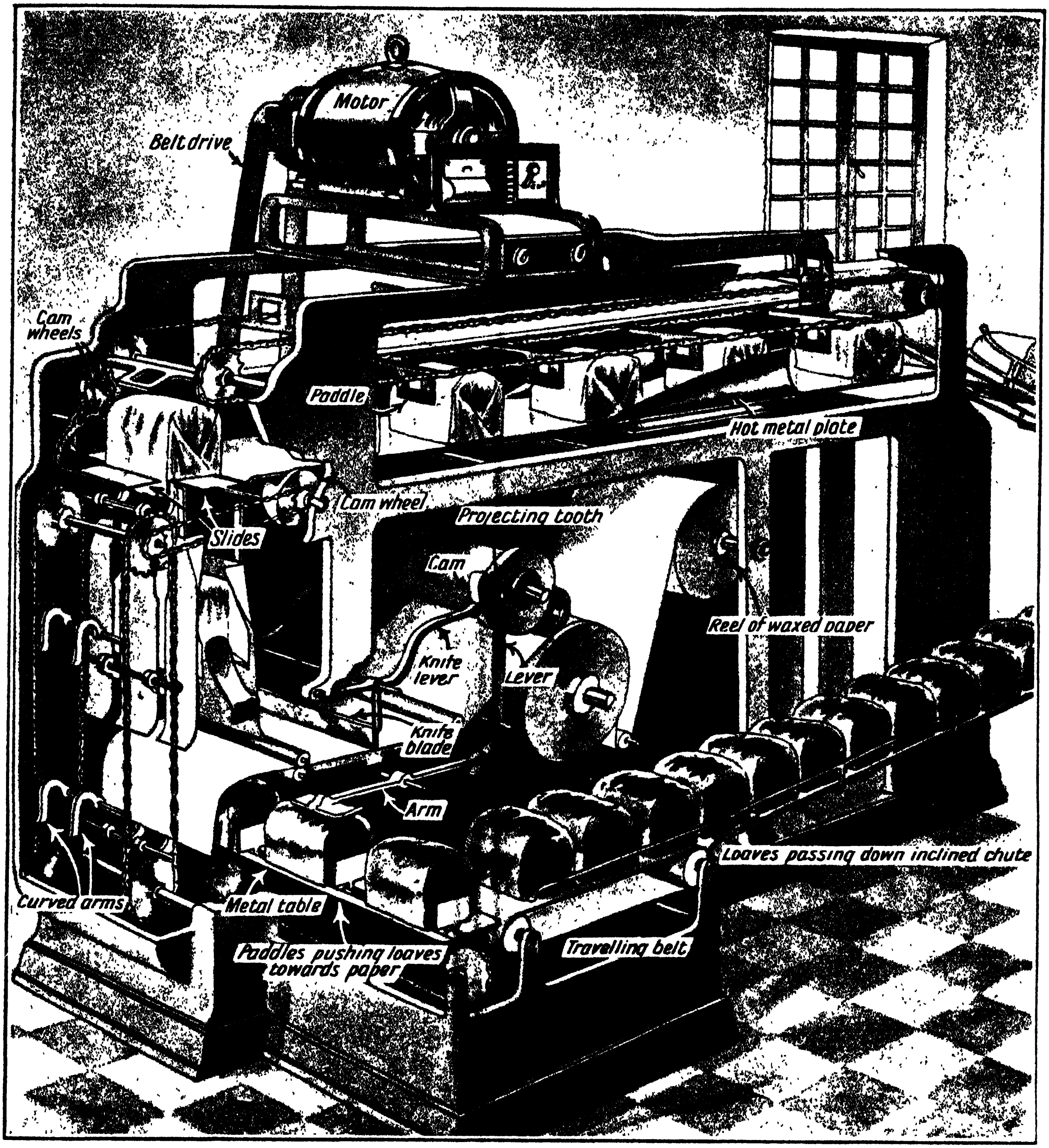
The vehicle on the platform presses down the transfer lever and operates a series of levers on the recording machine showing the number of tons. At the same time a device is set in operation which indicates on a scale the particular notch into which a part of the apparatus called the poise is to be put. The man in charge places the poise in its notch, and if a mistake is made and the poise placed in a wrong notch, a pointer directs attention to a notice : " Wrong notch. Move slide back (or forward) one notch." As soon as the poise is in the right notch the odd quarters and pounds are shown, and thus the exact weight of the vehicle is recorded

A COMPLETE FIRE BRIGADE ON FOUR WHEELS



Although it looks more like a motor-coach with its enclosed accommodation for the crew, this Merryweather fire engine is one of the most efficient of fire-fighting appliances and since 1950 large numbers have gone into service with fire brigades in all parts of Britain. The vehicle is 25 feet 6 inches long, including the escape overhanging the rear, and with all its equipment on board weighs eight tons. It is driven by a diesel engine which develops 125 horse-power to give a maximum road speed of 50 miles an hour, and by means of a clutch the power from the engine can be switched to the pumping gear which can pump water at a rate of 1,080 gallons per minute. The escape, which is released and removed from the engine by simply pulling a lever, can be extended to a height of 55 feet. Over the rear axle is a tank holding 100 gallons of water; this water is pumped through two 250-foot rubber hoses carried on a reel and is used on minor fires or until the engine's main hoses are connected to street hydrants. Arranged round the side of the body are lockers containing tools, tarpaulins, salvage equipment, oxygen bottles, and first-aid kit. In the cabin there is accommodation for a driver, officer, and four firemen. The cabin also has a radio-telephone transmitter and receiver so that the crew can keep in touch with headquarters or with other fire-engines. There are two bells, one on each side of the cabin Other equipment includes two hook ladders for climbing up the outside of buildings from window to window, a powerful searchlight, and a heavy suction hose through which water can be pumped from ponds and tanks. Another type of fire appliance, called a turntable, is described and illustrated on page 1300

WRAPPING UP THE LOAVES BY MACHINERY



This picture shows the remarkably ingenious machine which wraps loaves of bread in paper ready for delivery without their being touched by hand. The loaves slide on rails down an inclined chute and are carried by a short travelling belt on to a metal table with a slit in it. Along this slit travel paddles attached to an endless chain running round toothed wheels. A paddle pushes each loaf along and under an arm which is forced up by the rounded top of the loaf. When the arm goes up its other end depresses a lever, which, coming forward, disengages a projecting tooth on a wheel which now revolves, allowing waxed paper to run between rollers. After making one revolution a cam on the wheel raises a knife lever, the blade at the other end coming down and cutting the paper to the required length. The piece of paper is drawn over the loaf, which is raised by two curved arms travelling on a vertical endless chain. The loaf, with the paper, rises into a chute where a projecting piece of metal on either side makes the first fold, the inwardly bent sides of the chute folding over the paper at the sides. Arriving at the top of the chute, four slides, which are made to move to and fro by cam wheels, take the loaf off the curved arms, which drop back through a slit in the chute to travel round and up again. The slides go underneath the loaf, folding the paper under it and holding it up for just the fraction of a second, in which time another paddle comes round on an endless chain at the top of the machine and forces the loaf on to a table. A paddle carries the loaf before it, forcing it between two curved metal projections, which are heated by electricity. The table is also heated, and the waxed paper is momentarily melted and stuck at three places, that is at the sides and underneath. The paddle then forces the loaf into a delivery chute. The sketches for this drawing were made by courtesy of Messrs. J. Lyons & Co., Ltd., at their works

THE MARVEL OF THE SURE-FOOTED CHAMOIS

The chamois of the Alps and other European mountains must be the most sure-footed of animals. Their hoofs, having the outer edges higher than the central part, enable them to obtain a secure foothold and to stand on a very small space. They are often seen, as in the picture, perched steadily on a mere point of rock, and it is said they can bring their four hoofs together and stand on a space only a fraction bigger than a half-crown. The chamois are very agile, and can spring from crag to crag with surprising speed. Sometimes they slide down a slope as one is doing in the picture, and this operation is called glissading. They go about in small herds

THE NIMBLE CHAMOIS OF THE ALPS

The chamois is the most interesting of all the wild mammals of Europe. It is of course found in other European mountains besides the Alps, and it is also found in Asia Minor, but it is chiefly as an Alpine animal that we think of the chamois. Here we read many interesting facts about it

PERHAPS the most notable thing about the chamois is its extraordinary sure-footedness. It can leap from crag to crag in an astonishing way, never missing its foothold, and it can bring its four hoofs so closely together that it can actually stand upon the space of a 5s. piece, or a circle rather more than the diameter of a half-crown.

Some people think of the chamois as a goat, but it is really an antelope, although in size and appearance it is something like a goat. It stands about two feet high at the shoulder, and a full-grown buck weighs about 65 pounds, but specimens have been shot weighing more than a hundredweight.

Both sexes have black horns, seven or eight inches in length, although sometimes these are as long as a foot, and in the male they are rather thicker than in the female.

The chamois is very strongly built and has long and stout limbs. Its hair, which is close and rather long, with a thick woolly fur underneath, is brown on the back and lighter below, but in winter it changes colour and gets longer. It becomes almost black, and in December is three times as long as it is in July, so that the animal in winter looks quite burly.

A Beard on the Back

Then along the backbone of the male the hairs in winter grow very long indeed, and stand upright, waving in the wind. They then form what is known as the "beard," much prized by tourists, many of whom ignorantly suppose that it grows on the lower jaw, like a billy-goat's beard. The tips of the hairs in this "beard" are white, and the hairs are sometimes as long as nine inches. It is unfortunate that the fine bucks bearing the best specimens of these much-sought trophies are picked out for shooting by sportsmen.

The chamois shows much curiosity, and one Alpine sportsman tells us that he has seen a keeper with a black cloak thrown over his body, and moving about on his hands and knees, gradually beguile a three-year-old buck to come close up to him. This is a wonderful achievement, for the chamois is not an animal that it is easy to approach closely.

The chamois found in the Pyrenees, which is known as the izard, is really only a smaller form of the Alpine chamois. In the Caucasus the animal is known as the atchi. Unfortunately, owing to the exploits of sportsmen, the chamois is becoming rare in the Swiss Alps, though in the Eastern Alps it is more common.

The idea that the chamois lives only at great heights where there are glaciers and snowy peaks is quite mistaken. As a matter of fact, it is really a forest-dwelling animal, and most chamois live from year's end to year's end within the limits of the forest. During summer, however, a certain number go for a few weeks or months up into the heights among the glaciers and snowfields. A short spell of severe weather will soon drive them back to the shelter of the forest.

The chamois is a social animal, and loves to live in herds. Fifteen or twenty are often seen at a time, and they appear to get a great deal of fun out of leaping from pinnacle to pinnacle, and also in sliding, or glissading, as it is called, down the snowy slopes.

The animals sleep during the night, but are awake and out feeding by the first glimmer of dawn. Then when the Sun is up at midday they retire to the shade and lie down till evening, when they once more set out to feed. They live principally on the lichens and scanty herbage of the mountains.

For the greater part of the year the old bucks live apart from the flocks, but at the pairing season they once more join the flocks and soon drive away the young bucks. Often they will engage in fierce contests with other males, butting one another with their heads, and sometimes sending an enemy hurtling over the precipice.

When alarmed the chamois gives a shrill whistle, and the whole flock will then set off rapidly for safety.

A chamois in the Alps making its curious whistling sound

Balancing Power

That the wonderful power of balancing the body and the ability of measuring distances by the eye with unerring certainty which the chamois possesses are natural faculties inherent in the animal, and are not the result of training, is certain. Even the youngest chamois are able to follow their parents' lead, and the moment they possess the necessary strength, which is soon after birth, they can leap from crag to crag, and balance themselves on a pinnacle in the same way as their elders.

The young fawns, which are born in May or June, are able to follow their dams almost anywhere when but a day old, but it is three years before they attain their full size. Of course, the existence of a chamois is a hazardous one, but it is believed that their life often extends to twenty or even twenty-five years.

Occasionally a pine tree under whose branches the chamois takes shelter from the snow is borne down by the weight of snow, and the animal is buried and dies from starvation.

THE PINEAPPLE AND ITS SWORD-LIKE LEAVES

The lady who thought that pineapples were picked from trees was very much mistaken, as also was the merchant who complained to the pineapple grower about the quality of the fruits he was receiving. He declared that they were "windfalls." The pineapple, of course, does not grow on trees at all, but on the ground in the manner shown in the photograph on this page. It is a very interesting fruit, for what we call the fruit is not really one fruit, but a whole bunch of fruits clustered together.

The pineapple is a native of South America, but it is now found growing in many other parts of the world, as in the West Indies, the Hawaiian Islands, Africa and Asia. It can also be grown in greenhouses in Europe. It is said that the pineapple was first found, by Europeans, growing in Brazil, and that it was carried from there to the West Indies, and thence to the East.

It is not known exactly when it first came to England, but there is a painting in existence showing King Charles the Second being presented with a pineapple by his gardener, and tradition says that this was the first pineapple ever grown in England. That, however, is believed to be a mistake, and probably the pineapple presented to the King came from Holland, where the fruit was known some time before it was introduced into England.

For many years rich people in England grew their own pineapples under glass, and very fine fruits they were. It is said that an English grown pineapple is equal to any that can be found in any part of the world. Nowadays, however, when fruit can be brought in sound condition from every part of the world, the fashion of growing pineapples at home has died out.

The pineapple is very sensitive to cold, and it does not like air that is too dry. Attempts have been made more than once to grow it as a fruit crop in Southern California, but the attempts have had to be given up, and in the United States it only flourishes in the lower part of Florida, where they have no frosts, and where the air is very wet and humid.

The pineapple plants are grown in rows on little hillocks, and each plant bears its one fruit head on a stout central stalk raised about one foot above the ground. The fruit is surrounded by long, thick, sword-like leaves which have sharp prickly edges and are almost like a dagger at the tip.

When the pineapple fruits are gathered they have to be cut off the stem with a short hooked knife, and the men who gather them must wrap their legs round with thick cloth. Usually carpet is used for this purpose. Otherwise the pickers would get their trousers and legs cut and torn very badly. The men also have to wear thick mittens or gloves.

As the fruits are cut they are placed in bags carried by the harvesters or are thrown to other men outside the rows, who catch them and lay them carefully in crates.

As in the case of oranges, lemons, grapefruit and bananas, the pineapples are gathered unripe and they ripen while in transit to their destination. Those who have tasted a pineapple gathered ripe in the fields tell us that there is no comparison between its delicious flavour at such times and the taste of the fruit gathered unripe and allowed to ripen afterwards. The same applies to the other fruits named which are gathered unripe.

This photograph of a pineapple plantation in Florida shows how the fruit grows on a stout stem about a foot from the ground, and is surrounded by sharp, sword-like leaves, from which the fruit-gatherers must protect their hands and legs with coverings

The pineapple plant is not nowadays multiplied by means of seed, but by suckers or offsets that spring out around the base of the stalk and are taken and planted in the soil. The wild pineapple, however, produces seeds. As the plant grows from the centre of the leaf cluster there rises a short stout stem which at the flowering season produces a conical spike of flowers surmounted by a crown of small, spiny leaves. The berries which succeed the flowers grow together to form the fruit head we know so well.

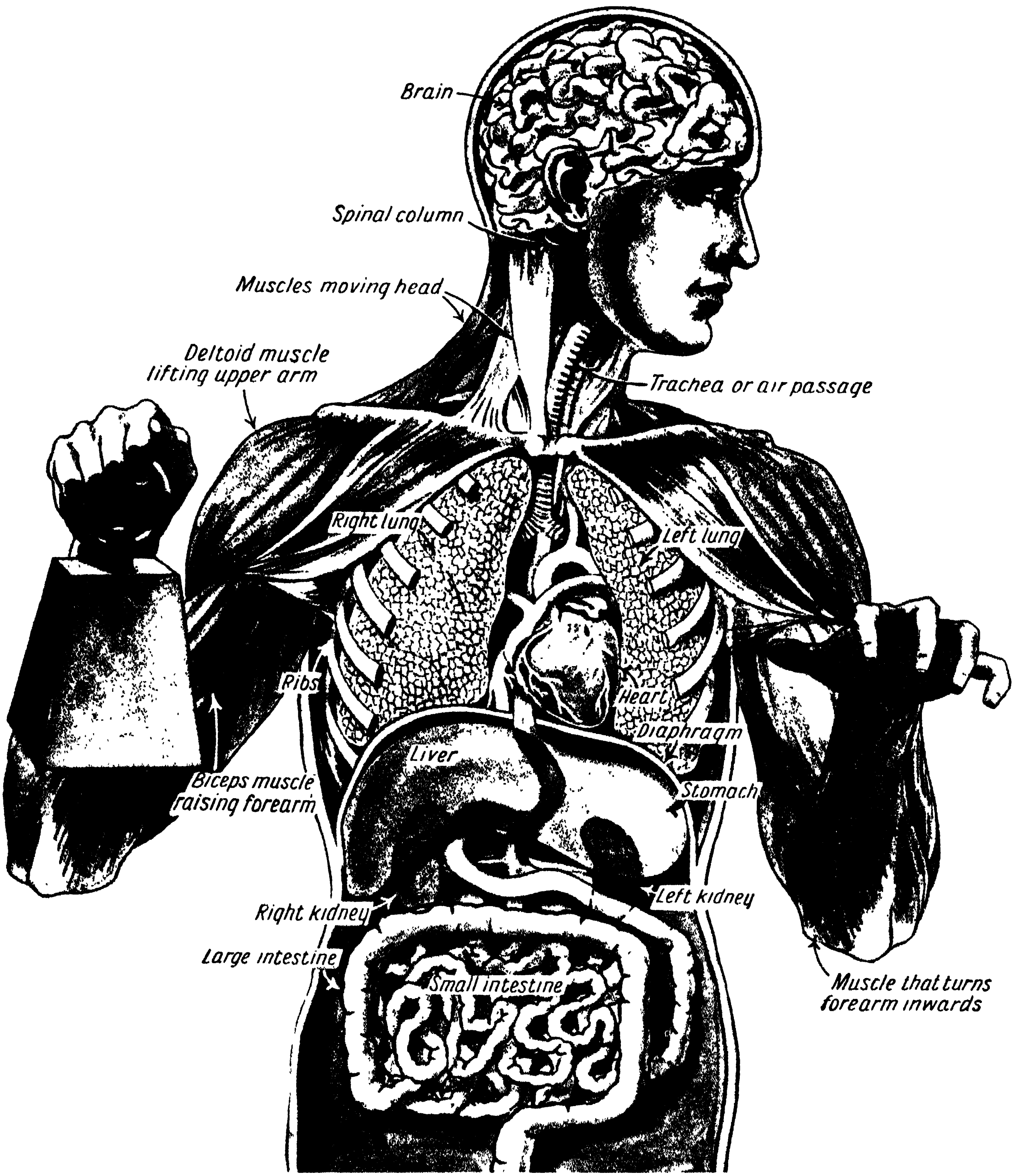
The leaves yield a very strong fibre from which the people of the Philippines make their celebrated pina, or pineapple cloth.

GIANT CRABS & LOBSTERS OF THE DEEP

The crabs and lobsters caught round the British Isles are not very large, but in other parts of the world some giants are found. The crab in the left-hand photograph was caught in a cray-fish pot in Australian waters. It measured 3 ft. 10 ins. across the claws and was so strong that it broke four metal wires of the pot. The lobster on the right was caught in American waters and weighed twenty pounds

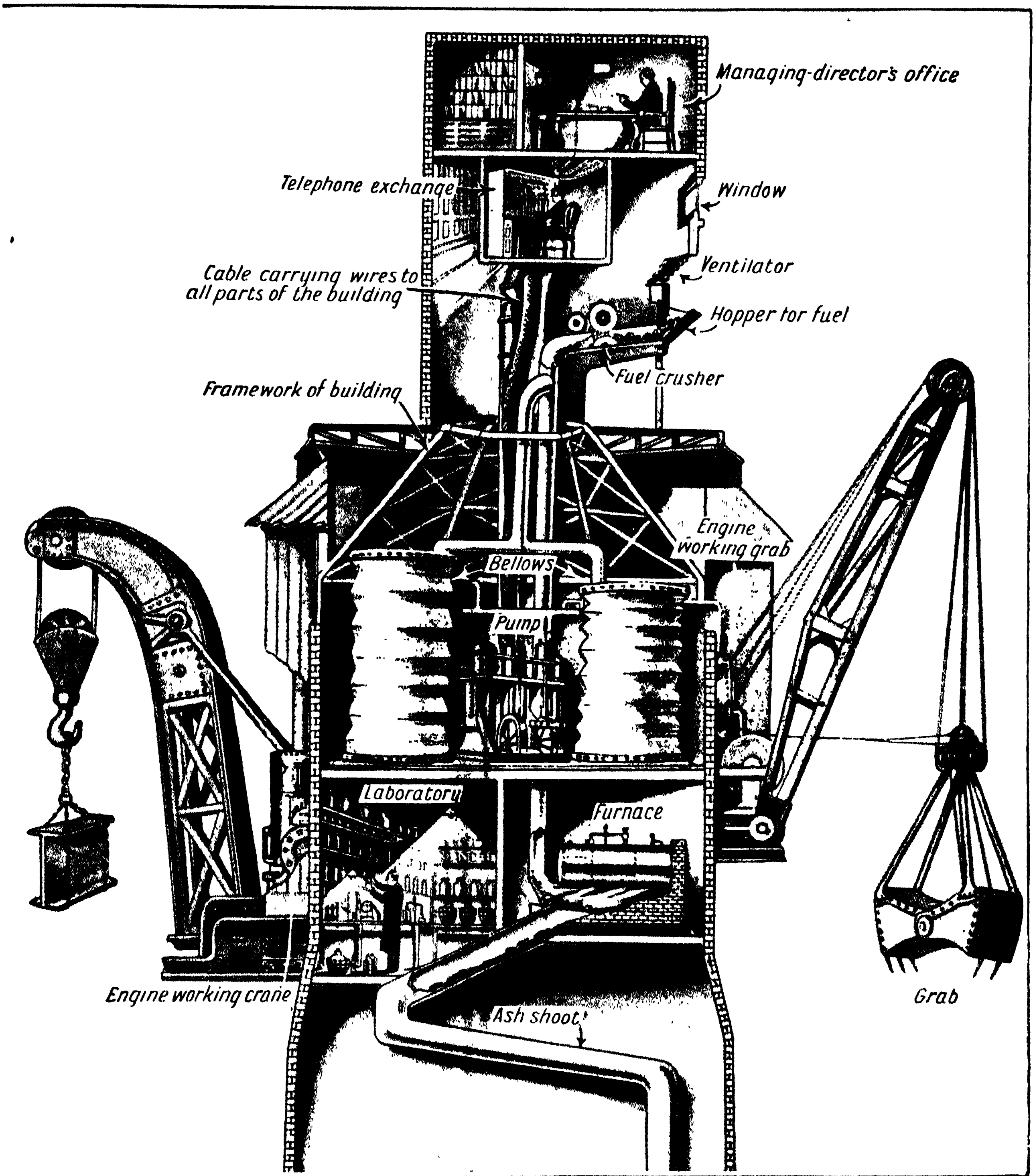
This is one of the great land crabs of the warmer parts of the world and it is known as the calling crab, from its strange habit of brandishing one of its claws, which is of much greater size than the other. It is the big claw that can be seen gripping the man's foot. This is not used, however, primarily as a weapon of attack. Only the males possess the enormous claw, and as it is brightly coloured, the waving is supposed to be a courtship display to attract the female crabs. These crabs live in burrows near the shore

WHAT YOUR BODY LOOKS LIKE INSIDE



The human body is the most wonderful thing in the universe. It is the most efficient of all machines, and unless it is damaged or spoilt by accident or misuse it goes on doing its work perfectly day after day, till at last, like all material things, it becomes worn out. But the machinery of the human body is extraordinarily delicate, and the more we know about our body and realise this fact, the more careful we shall be to see that it is not misused in any way by wrong living. We are often told that the heart which drives the life-giving blood through our bodies is an engine and pump, and that the stomach is a furnace. But when we look at a chart like this one showing the organs, it is rather difficult to realise that we are looking at a furnace, a pump, and other machinery. The picture-diagram on the opposite page will make the matter clear and vivid to our imaginations. By comparing the two pictures we shall see that it is no mere fancy or exaggeration to describe the human body as a great and wonderful factory. Perhaps the most marvellous thing about our body is the perfect way in which its various parts all work together. If any part gets out of order and ceases to function, as, for example, if we eat unsuitable food, thereby supplying wrong fuel to the furnace, or if we breathe bad air, so that the furnace cannot get sufficient oxygen for combustion of the fuel, then the whole factory becomes disorganised, and we say we are ill. We notice how the whole body is built round the bones of the skeleton in the same way as a factory is built on a skeleton of girders

THE HUMAN BODY SHOWN AS A FACTORY



In this picture, which corresponds to the form of the body, we see the functions of the various parts and how closely they correspond to the parts of a factory. A factory would be useless without some directing head, and our skull is like the managing director's office, for it is from the brain inside that all the work of the human factory is directed. There must be a telephone exchange so that messages can be sent to the right departments, and this we get in the lower part of the brain and the spinal column. Our eyes are like the windows of the office. Then the factory must be properly ventilated, and fresh air is taken in from outside through openings, as our body does through nose and mouth. To keep the machinery of the factory going there must be a furnace and engine, and so in our body the stomach and intestines form a furnace that must be supplied regularly with suitable fuel. In a factory the fuel is shot through a hopper and directed to the furnace, the coal being crushed to a suitable size. In the human body food, which is the fuel, is taken in through the mouth, broken up by the teeth, and then passes to the stomach, the unconsumed ash being disposed of. The lungs are the bellows that supply a sufficient quantity of oxygen for combustion, the heart represents the engine and pump, and various intricate chemical operations that go on are carried out in the laboratory, which consists of the kidneys and liver. Our arms and hands are like very powerful cranes and grabs for lifting or grasping things and moving them about

THE INSIDE OF A HEN AS AN EGG FACTORY

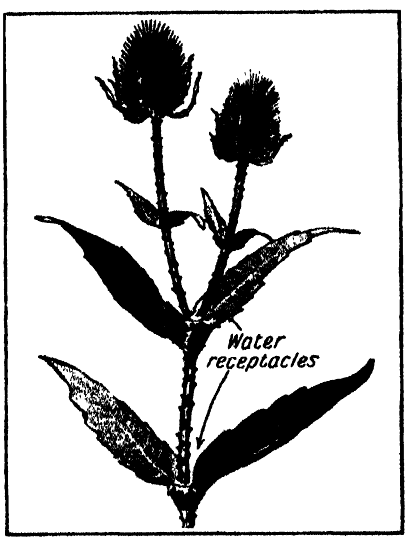
This photograph shows a large model of a hen which has been exhibited in different parts of the country to illustrate the way in which the eggs are produced. From the bird's brain a telegraph line, representing the spinal cord, runs to different parts of its body to carry messages. The entrance to the windpipe is represented by a pair of bellows, the heart is shown by a double pump, and the gizzard by a grinding machine. The parts of the hen's organs which produce the egg are shown as a series of chambers. In the first the yolks are being made, in the second department they are wrapped round, in the third chamber the white is pumped into the enclosing membrane, and, finally, before the egg is ejected, the outside is being plastered with material to form the outer shell. The model is called "The Egg Factory," and it is interesting to compare it with the picture-diagram of the human body as a factory shown on pages 746 and 747

HOW THE TEASEL KEEPS OFF INSECT THIEVES

THE common teasel which is to be seen growing abundantly in many parts of Southern England, but less frequently in the North, is a very picturesque plant. It grows to a height of from three to six feet, has an erect prickly stem and large bright green leaves which are prickly underneath. The flower heads are very striking, being large and conical and covered with straight bristles. They are lilac in colour, and later develop into stiff seed heads, which we sometimes see dyed various colours and put into vases by way of decoration.

The fuller's teasel, a cultivated variety, is similar, but has a more cylindrical head, with hooked bristles It is used for dressing cloth, and although machines to do the work in imitation of the teasel have been made, no satisfactory substitute for teasel dressing has yet been found.

But perhaps the most interesting thing about the teasel is that the pairs of leaves have their lower parts joined to form a receptacle in which rain and dew gather, having run down the stem. In these little lakes various creeping insects are caught and drowned, and are thus prevented from crawling up the stem to steal the honey in the flowers. The honey is thus preserved for flying insects, which will help the plant by carrying pollen from flower to flower and thus do the work of fertilisation



The common teasel which grows wild in many parts of England

Another species of teasel that grows wild in various countries of Europe

THE KING WHO HID IN AN OAK TREE

The adventures of King Charles the Second after his defeat by Cromwell at the battle of Worcester form a great romance as thrilling and exciting as any novel, and here the story is told with a great deal of detail. Few monarchs have ever experienced such ups and downs of fortune

LAWLESSNESS always begets lawlessness, and after Charles the First had lost his head through breaking the law, those who seized the power were compelled to hold it illegally

Oliver Cromwell's army had been created by the Parliament, and for a time Cromwell tried to keep up the pretence that the Parliament was governing England, but when the Members would not carry out his orders he found that Parliament must be dispensed with altogether So one day he went down to the House of Commons of which he was a Member, dressed not as a soldier, but in plain black cloth and grey worsted stockings He took with him a body of soldiers, and, leaving the troopers outside, he entered the Debating Chamber and sat down. After listening for some time to the debate, he rose in his place and began to speak.

First of all he praised the Parliament for the care it had shown in looking after the public good, but soon changing his tone, he declared that it had been stained with "injustice, delays of justice, and self-interest."

A Member interrupted "It is strange language, this," he said, "unusual within the walls of Parliament and from a trusted servant too, one whom we have so highly honoured, and one——" He was unable to finish his sentence, for the Lord-General Cromwell stopped him.

"We have had enough of this!" he exclaimed "I will put an end to your prating," and stepping forth upon the floor of the House, he stamped his foot. "It is not fit that you should stay here any longer," he said. "You have sat too long for any good you have been doing lately You shall now give place to better men." Then, turning to a fellow officer, Colonel Harrison, he said, "Call them in," and Harrison gave a word of command which caused some twenty or thirty musketeers to enter with weapons ready loaded for use.

"You call yourself a Parliament!" said Cromwell in blazing tones. "You are no Parliament. I say you are no Parliament. Corrupt, unjust persons; scandalous to the profession of the Gospel How can you be a Parliament for God's people? Depart, I say, and let us have done with you In the name of God, go." Then going up to the mace, the very symbol of Parliament's authority, Cromwell said, "What shall we do with this bauble? Take it away," and, lifting it, he handed it to a musketeer, who carried it off

Seeing resistance was useless the Members passed out, Cromwell denouncing many of them individually as they went.

"It is you that have forced me to this!" he exclaimed, and going out he locked the door and took the key.

It was the end, for the time being, of the Long Parliament, which only reassembled after Cromwell's death

During the night some wag fixed a paper to the door of the Parliament House bearing the words "This House to Let."

Soon afterwards Cromwell was made Lord Protector, and although he tried

Charles discovering himself to Colonel Windham's family after his defeat at the battle of Worcester. From the painting by Stothard

to continue the outward forms of Parliamentary government he more than once dissolved Parliaments that he summoned when he found the Members would not obey him But though Cromwell ruled with a high hand it must always be remembered that, unlike the Stuart kings, he made his country feared and respected throughout Europe When the Duke of Savoy cruelly persecuted his Vaudois subjects because of their religious views, and Milton wrote his famous poem beginning

> Avenge, O Lord, thy slaughtered saints whose bones
> Lie scattered on the Alpine mountains cold,

Cromwell sternly told the French Minister, Cardinal Mazarin, that if he wanted peace with England this persecution must stop Mazarin at once saw to it that the Duke of Savoy ceased his persecution and gave his subjects liberty of worship No Stuart king's word, either before or after Cromwell, ever had such weight in the counsels of Europe.

Meanwhile, what was happening to the young Prince of Wales, Charles the First's eldest son, who later came to the throne as Charles the Second ?

A Crown for a Promise

He was a penniless exile on the Continent, afraid to put a foot in England so long as Cromwell lived In the year following his father's execution he had gone to Scotland, where he had been proclaimed King, and was crowned at Scone ; but before the ceremony took place the Scots had exacted all sorts of promises from the young prince, which he certainly never intended to keep

At this time, when he was nineteen years old and over six feet in height, he is described as ugly, dark and hairy, with a long nose and large, brown eyes. He was poorly educated and had little money, but he was blessed with plenty of wit and a good deal of natural ability.

The Scots made him promise to be a Presbyterian and to live according to their strict and gloomy rules. Wherever he went he was watched to see that he behaved properly and was constantly scolded and preached at. He had to spend hours in church at long prayers, and was compelled to observe the Sunday more strictly than a Jew observes the Sabbath. Even if he smiled on Sunday he used to be reprimanded by his Scottish supporters, and not only were they constantly denouncing his late father and his mother in their sermons and prayers, but they compelled him to show approval of such denunciation.

The Prince was a great pleasure-lover, and even amid his strict surroundings could not altogether act the hypocrite On one occasion he played cards on a Sunday and was seen through an open window by a shocked lady, who informed her minister The minister went across to rebuke Charles, but the worthy man must have had a sense of humour, for after a long and severe admonition he added, " When your Majesty wishes to indulge in card-playing or the like ungodly recreations you must take the precaution to—shut the window."

Charles hiding in the oak-tree at Boscobel while Cromwell's soldiers vainly hunt for him below

Cromwell marched into Scotland and defeated the Scottish army at Dunbar, charging into their midst with the cry " Let God arise ; let His enemies be scattered ! " Then after a visit to Edinburgh he pursued Charles and his army into England and inflicted a crushing defeat on them at Worcester.

The Scottish army was absolutely destroyed and most of those who were not slain were taken prisoners and later sent as slaves to Barbados. " The dimensions of this mercy," wrote Cromwell, " are above my thought. It is for aught I know a crowning mercy " Certainly Cromwell never again had to fight a battle in England.

What happened to Charles after the battle of Worcester ? Well, he escaped from the scene and eventually made his way to France, but before doing so had some of the strangest adventures which have ever happened to a king

For six weeks he wandered about in the west and south of England, hiding in unlikely places and facing the risk of capture by his enemies every day. Only the loyalty of a few subjects, some of high rank and some of very humble station, saved him. Large rewards were offered to any who should capture the fugitive, and during the six weeks he was in hiding he was in the midst of people who would gladly have given him up to win the money offered for his capture They were dangerous and exciting experiences that he went through, and in after years he loved to tell the story. But we are anticipating.

Charles had behaved with great gallantry at Worcester, and one of his officers wrote, " Certainly a braver prince never lived, having in the day of the fight hazarded his person much more than any other officer of his army, riding from regiment to regiment and leading them on upon service with all the encouragement that the example and exaltation of a magnanimous general could afford "

The Flying Scotsmen

He even tried to rally the Scottish Horse after the rout, but nothing could stay the flying Scots " Men who had deserted me when they were in good order," said Charles later, " would never stand to me when they had been beaten," and after the day was lost and Charles and a few companions tried to make their way to London before news of the defeat could reach the capital, they found the greatest difficulty in detaching themselves from the stampeding Scottish cavalry With some sarcasm Charles said of them, " Though I could not get them to stand by me against the enemy, I could not get rid of them now I had a mind to it."

However, with about sixty gentlemen and officers he slipped away from the Scots under cover of darkness and made his way to Whiteladies, a house belonging to a Roman Catholic family named Giffard. Several branches of the family lived there, and a number of other people, including two servants named John and George Penderel. When, about three o'clock in the

morning, the King and his party arrived at Whiteladies and knocked on the gate it was George Penderel who answered the summons He saw in the party his brother-in-law, Francis Yates, and asked " What news from Worcester ? "

" The King is defeated and is here," replied Yates, and thereupon the King and others flocked into the hall The household was roused and a meal of bread, cheese and sack was provided Then another of the Penderel brothers, Richard, who lived close by, was sent for and also William Penderel, the father, who was at another house owned by the Giffards, known as Boscobel

It was decided that Charles must disguise himself, and a rough suit of clothes was procured, his hair was cut short with a knife by Lord Wilmot, and his hands and face rubbed with soot taken from the chimney. The clothes he donned included a coarse shirt belonging to one man, and breeches of coarse green cloth and doeskin, together with a leather doublet be longing to another

Charles disguised as a man-servant riding with Jane Lane after his defeat at the battle of Worcester From the painting by Ward in the House of Lords

Bad Shoes

All were the worse for wear, and the grey stockings he put on were very much darned and the shoes patched in many places. The shoes had to be cut before Charles could get his feet into them, and in the next few days they chafed his skin so badly that he could hardly walk A long white steeple-crowned hat with only grease for a lining, and both sides of the brim so doubled with handling that they looked like two spouts, completed his outfit. At least four men had contributed to the King's wardrobe.

The King's hair had been so hacked by Lord Wilmot or, as the old account says, " untowardly notched " that Richard Penderel had to trim it with a pair of shears to make it less unsightly and noticeable. We are told that " the King was pleased to take notice of Richard's good barbering so as to prefer his work before my Lord Wilmot's, and gave him praise of it."

Charles's own clothes were buried in the garden, and he was then given lessons " to alter his steps and straight body to a lobbing Jobson's gait," and to speak like a rustic. Then the various members of Charles's party, realising it would be unsafe to remain together, left one by one in different directions, and Charles himself was led by Richard Penderel to a coppice half a mile away, where he was given a bill-hook so that if any saw him they might think he was a mere peasant.

Not long afterwards a party of Roundheads galloped up to Whiteladies and asked if anything had been seen of the King They were told that a troop of Horse had called there three hours before and that Charles was with them, but that they had gone off immediately, and the Penderel brothers managed cleverly to persuade the pursuers to continue their journey.

Charles's position was not a pleasing one, for though there was no further alarm for a time the rain poured down so constantly that he was completely soaked to the skin A meal of milk, eggs and sugar was carried to him, and Charles continued to take lessons in rustic speech, but he found it very difficult, and to acquire the habit of walking awkwardly was still more difficult.

The next evening Charles was escorted to another house known as Hobbal Grange, where he was to pass as " Will Jones, wood-cutter, newly come thither for work." He sat down in the kitchen by a warm fire with a little child, Nan Penderel, on his knee, and watched his hostess frying eggs and bacon for supper.

Charles had intended to go to London, but he now altered his plans and determined to cross the Severn into Wales. With Richard Penderel Charles started on foot at nine o'clock at night, but when they had gone only three miles they saw a white figure in the doorway of a mill who called out. " Who goes there ? " It was the miller, and Richard replied " Neighbours going home "

" If you be neighbours, stand," cried the miller, but Charles and Richard Penderel at once took to their heels, whereupon the miller called out " Rogues ! " and a party of men coming from the mill gave chase

" We fell a-running," says Charles in telling the story, " both of us up the lane as long as we could run, it being very steep and very dirty, till at last I bade him (Richard) leap over a hedge and lie still to hear if anybody followed us "

They were not pursued, for the miller had been as frightened as they were He was a Royalist supporter, and had some fugitive Royalist soldiers hidden in the mill He had mistaken Charles and his companion for Cromwell's men

In due course Charles and Richard reached the house of a Royalist supporter, Mr Wolfe at Madeley, but learned to their dismay that Parliament soldiers were stationed in the district and it was unsafe to go farther

Over the Water

During the day Charles hid in a barn, and at night after a meal, prepared to return to Boscobel Mrs Wolfe stained his face and hands with the juice of walnut leaves and her husband gave him a pair of green yarn stockings which he hoped would chafe the King's feet less than the rough grey worsted stockings he had on.

At eleven o'clock at night the pair started for Boscobel Not wishing to meet the miller again, Charles decided that it would be better to wade across the stream that lay in the way instead of going by the bridge, but Richard, who thought this " a scurvy river not easy to be passed," hesitated " Upon which," says Charles, " we went over some closes to the riverside and I, entering the river first to see whether I could myself go over who knew how to swim, found it but a little above my middle, and thereupon taking Richard Penderel by the hand I helped him over."

The King's feet were now so sore and his stockings so full of sand that he could hardly walk. So great was his pain that he actually sat down on the ground and implored Richard to go on alone, declaring that he would rather

die than walk another step, but Penderel stuck by him and persuaded him to struggle on as far as Whiteladies

Then they continued to Boscobel and arrived there about three o'clock in the morning Charles waited some little distance away while Richard went on to see if any soldiers were in the house Not long afterwards Richard returned with a Colonel Carlos who had done gallant service at the Battle of Worcester The comrades entered the house where Charles took "a posset of thin milk and small beer," while his feet were washed and his shoes and stockings dried

It was realised that at any moment Parliament troops might come to search the house and it was, therefore, decided that Charles and Carlos should go and hide in an ivy-covered oak which stood some distance away in the wood By means of a ladder the King climbed on to a high bough with the Colonel, a couple of pillows were handed up to make their sojourn more comfortable, and they had also some bread and cheese with them. It was a good thing that Charles hid in the oak, for not long afterwards soldiers arrived to search the wood. They were skilfully diverted by one of the Penderel women.

Pinching the King

Charles, who was exhausted by his three nights of hardship and watching, fell asleep in the Colonel's arms, and we are told that he slept so long and so soundly that the Colonel became numbed by his cramped position. He was afraid that he might let Charles fall from the tree, and yet he feared to speak loud enough to wake the king lest the soldiers searching below should hear him He was, therefore, "strained to practice so much incivility as to pinch His Majesty to the end he might awake him to prevent his pressing danger "

It was a queer position for a king, and his sojourn in the tree has been commemorated annually ever since, on May 29th, his birthday and the day on which he entered London when restored to his throne It is called Oak-apple Day, and many people still wear a sprig of oak to celebrate the occasion.

At evening Charles and his companion returned to the house and learned that a colonel of the Commonwealth Army had been making inquiries at Whiteladies, asking if the King had been there and pointing out that the penalty for concealing him was death without mercy, while the reward for discovering him was "one thousand pounds certain pay."

Humphrey Penderel who had obtained this news, put the King at his ease by declaring that even if the reward were one hundred thousand pounds the King would still be safe with him and his family That night Charles rested in a secret hiding place in the house, a recess in the chimney-stack, but he slept "very incommodiously, with little or no rest, for that the place was not long enough for him," and he rose very early.

The King, who had eaten very little during the last day or two, suddenly had a longing for mutton, but the Penderels possessed no sheep of their own and they were afraid to buy one in case the curiosity of their neighbours should be roused. They, therefore, decided to go out and steal a sheep from the flock of one Staunton, who rented part of the Boscobel estate. They did so, killed the beast and brought a leg of mutton to the King.

Well," said Charles, "if the rogue be taken he deserves to be hanged, to which the smith agreed

Charles was delighted, and himself cut some collops or slices from the leg, pricked them with the knife-point and, calling for a frying pan and butter, fried the meat himself. Colonel Carlos turned the collops while the King held the frying pan, and we are told the incident "yielded the King a pleasant jocular discourse after his return to France when it amounted to a question, a very difficult case, who was cook and who was scullion." When his friends could not agree Charles declared that he himself had been both.

Some time afterwards William Penderel offered to pay the price of the sheep to Staunton, but when that worthy understood that his beast had been taken to relieve the wants of distressed cavaliers, he generously declined to accept anything.

It was unsafe to remain at Boscobel, so on the Monday the fugitive set off accompanied by some of the Penderels for Mosley Hall, which was occupied by a Mr John Whitgreave, a Royalist supporter.

Loyalty Rewarded

Charles took leave of the faithful Penderels declaring "if ever I come into England again by fair means or foul, I will remember you," and it is interesting to know that he kept his word, for he granted to them and their descendants for ever a pension, and members of the Penderel family in America and Australia are still receiving this.

The King's feet were so sore that he had to ride to Mosley Hall. He had a roll of paper between each pair of toes to keep the skin from chafing, and when he arrived at the Hall a priest in hiding there bathed his feet and anointed the blisters. After a time the feet were easier and Charles said he felt "fit for a fresh march."

It was arranged that Charles, disguised as a servant and answering to the name of Will Jackson, should ride with a Miss Lane to Bristol, and the next day he went off to the house of her brother, Colonel Lane, to start this part of his wanderings. On the journey to Bristol Charles often forgot the part he was supposed to be playing, and Mistress Lane herself nearly betrayed the King by her deference in his presence.

During the early part of the journey the King's horse cast a shoe, and the party had to halt at a smithy to get it replaced. While Charles was holding the horse's hoof he asked the smith "What news ? "

"Why, nothing," said the man, "save that the Lord General have routed the Scots."

Charles inquired if any of the Royalists had been captured and was

told that some had been caught but not "that rogue Charles Stuart."

"Perhaps," suggested Charles, "he hath got by the byways back into Scotland."

"No," answered the smith, "that is not likely. He rather lurks somewhere in England, and I wish I knew where, for I might get a thousand pounds by taking him."

"Well," replied Charles, "if the rogue be taken he deserves to be hanged more than all the rest, for bringing in the Scots."

"You speak like an honest man," cried the smith, and they parted good friends, very pleased with one another.

Near Wotton the riders, who, in addition to the King, consisted of Mistress Lane, her cousin Henry Lascelles, and her brother-in-law and sister Mr. and Mrs. Petre, saw ahead a party of Parliament soldiers resting while they fed their horses. Charles and Mistress Lane wanted to go on boldly, but the others were too terrified and they turned aside. Later they saw the troops again and had to pass right through their midst, but there was no interference.

At Stratford-on-Avon the Petres left the party, while the others went on. At Long Marston, where they stayed the night at the house of a Mr. John Tomes, Charles sat in the kitchen and the cook bade him wind up the roasting-jack. He started turning it the wrong way, upon which she demanded angrily "What country man are you that do not know how to wind up a jack?"

"I am a poor tenant's son of Colonel Lane in Staffordshire," he replied. "We seldom have roast meat and when we do we don't use a jack."

This seems to have satisfied the cook. The party passed safely through Bristol and arrived at Abbots Leigh, three miles beyond the city where lived a Mr. and Mrs. Norton, staunch Royalists. The secret of Miss Lane's attendant was imparted to them, but their servants were not informed.

The Man Who Knew the King

The next morning in the buttery, while Charles was having breakfast with the butler and others, a man began talking about the Battle of Worcester, and it was evident from his description that he had been present. He turned out to have been a trooper of the King's regiment.

"Have you ever seen the King?" asked Charles.

"Twenty times," returned the other.

"What is he like?" asked Charles, and the man replied by giving an exact description of the King as he appeared at the battle. Then, he added, "The King is just four fingers' breadth taller than you."

Charles was anxious at the man's garrulity and made some excuse to leave the buttery as soon as he could.

Later, when passing through the hall with the butler, he had to raise his hat to Mrs. Norton, and at this the butler gave a start, gazing earnestly at the King's face. It seemed evident that the butler knew the identity of the visitor. He was known to be loyal and it was therefore decided to tell him the truth, so that he might not cause any unpleasant complications, and he thereupon kissed the King's hand and protested his loyalty.

Attempts were made to find a ship at Lyme, Bridport or Southampton, to carry the King to France but this was impossible as the only available vessels at all these ports had been seized to take Cromwell's soldiers to Jersey. It was arranged, however, that a ship should be ready at Shoreham to carry the King across the Channel and Charles, therefore, went to Shoreham, and stopped for a night at Brighton, where he was recognised by the inn-keeper, who suddenly kissed his hand and said "God bless Your Majesty wherever you go."

Going aboard the King rested in a hammock. "But I was no sooner laid down," he says, "than the master came to me, fell down upon his knees and kissed my hands telling me he knew me very well, and would venture his life to set me down safe in France."

The wind was favourable, the passage of the Channel was made safely, and the King soon reached Rouen, whence he departed for Paris, meeting his mother, Queen Henrietta, on the way. Then, in 1660, he was welcomed back to England to occupy the throne of his father, so long without an occupant.

King Charles the Second landing at Dover on his return from exile From the painting by Benjamin West

6499

THE PEAKS OF NATURE & THE PEAKS OF MAN

There is an amazing resemblance, at a distance or in a photograph, at any rate, between the peaks and pinnacles that are sculptured by Nature from the solid rock and the towering skyscrapers and spires erected by man in imitation of Nature's work. Compare, for example with the picture below this photograph of the "Silent City" in Bryce Canyon, U.S.A. It certainly resembles a city of skyscrapers

This wonderful recent photograph of New York shows how the skyscrapers are spreading over the city and are rising to ever greater heights. The building with the spire on the right is the Chrysler Building, which outstripped a rival in height at the last moment by having the spire built up inside its walls and then having this structure hauled into position, to the astonishment of all beholders

WHY THE SUN SWINGS NORTH & SOUTH

Our summers are warmer than our winters because in summer the Sun passes across the heavens higher up than it does in winter, and so the rays of light and heat come to us much more directly. In these pages we see the reason why the Sun is higher in the heavens in summer than in winter. The picture-diagrams will help to make the matter perfectly clear

As the Earth travels round the Sun its axis is tilted at an angle of 23½ degrees from the perpendicular and this has a number of striking effects. It causes the inequality of day and night at different seasons of the year. It results in the regions round the North and South Poles having continuous daylight for nearly six months, and then continuous darkness for six months. It also has the effect of giving us, in the northern half of the world, colder weather when in winter we are three million miles nearer the Sun, and warmer weather when in summer we are three million miles farther away. This latter seems a very strange thing, but we see the reason for it later.

To get an idea of how the Earth moves round the Sun we can carry out a simple experiment. Let us take a round tub or large basin and fill it with water. In the centre of this basin let an india-rubber ball float. Then take a small round tangerine and stick a knitting-needle through it from top to bottom. Now put the tangerine in the water at the edge of the basin or tub and tilt the needle at an angle of about 23½ degrees from the perpendicular.

Round the Tub

Allowing the india-rubber ball, which represents the Sun, to remain stationary in the middle of the water, gradually move the tangerine round the tub, keeping the knitting-needle at the same slant all the time and pointing in the same direction. The tangerine represents the Earth, and as we move it round the water in the way described, it is a very good representation of the way the Earth travels round the Sun.

Now if we draw round the tangerine a line midway between the top and bottom to represent the Equator, a slice cut from the tangerine through the Equator would be at an angle to the surface of the water. The water in which the ball and tangerine representing the Sun and Earth are floating is a picture of the plane or level in space in which the Earth travels round the Sun, and that plane or level is called the Plane of the Ecliptic. On the other hand, the slice through the tangerine cut midway between the top and bottom represents the plane or level of the Earth's equator which is at a slant to the ecliptic and is called the Plane of the Equator.

The Plane and the Ecliptic

The word plane, of course, simply means flat or level, and the word ecliptic was given to the plane or level of the Earth's orbit because eclipses only occur when the Sun, Earth, and Moon are all in this plane.

We may prove for ourselves that the Sun swings north in summer and south in winter by watching the particular part of the horizon below which it sets. This picture shows the same landscape in summer and winter, and we can see by the position of the house and tree the movement of the Sun between summer and winter

Now if the axis of the Earth were upright, that is perpendicular to the plane of its orbit, so that the level of the ecliptic and the level of the Earth's equator were the same, things would be very different from what they are. For instance, day and night would always be the same length everywhere on the Earth and, furthermore, at all seasons of the year.

Then at noon of every day in the year the Sun at any particular place would always be at exactly the same point in the heavens, and it would always be vertically above some point on the Equator. As it is we know that the Sun at noon in England, for instance, is much higher up in the sky in summer than it is in winter, and so far from being always vertical above some point on the Equator at noon, this actually happens only on September 23rd and March 21st each year.

Owing to the Earth's axis being tilted to the plane or level of the orbit, the northern half of the Earth is inclined towards the Sun in summer and away from it in winter. The result of this is that on June 21st, when the Northern Hemisphere is inclined towards the Sun, his rays fall vertically at noon not on the Equator but on another line going round the Earth, called the Tropic of Cancer. This is 23½ degrees north of the Equator.

As the Year Goes On

Then as the year goes on the Sun's apparent path across the sky, day by day, seems to move south until on December 22nd, when the Northern Hemisphere is inclined away from the Sun, its rays fall vertically not on the Equator but on the Tropic of Capricorn, which is 23½ degrees south of the Equator. This apparent journey of the Sun's path north and south of the Equator each year is due entirely to the Earth's tilt.

We may prove for ourselves that the Sun's daily path thus swings north and south once every year, by means of two simple experiments. First of all let us select some open space from which we can see the horizon to the east and west. A school roof would be excellent, or if we are in fairly flat country, a field. Now by means of a

compass let us mark the four cardinal points so that we shall know when we are looking north, south, east or west. The point directly below the Sun at noon is south, and the point below the Pole Star is north. The points where the Sun rises and sets on March 21st and September 23rd are east and west respectively.

Knowing the direction of north, south, east and west, let us go into this open space—the roof or the field, or wherever it may be—every ten or fourteen days and note the place on the horizon where the Sun rises and where it sets, and also if possible the position in the heavens where it is at noon. We shall find that in winter the Sun rises and sets much farther south than it does in summer, and its position at noonday will also be lower in the sky, that is nearer the south, than it is in summer. In other words, we shall have proved for ourselves that the Sun's apparent path moves north and south at different times of the year.

In this picture-diagram we see in the lower part how the Earth's axis is tilted so that in summer the northern hemisphere slants towards the Sun, and more than half that hemisphere is illuminated. In winter the slant is away and less than half is illuminated

The Shadow of the Sill

The other experiment is to choose a room with a window facing the south, then mark upon the floor every ten or fourteen days the place reached by the shadow of the window-sill at noon. We shall find that in summer this shadow is much nearer the window owing to the Sun being higher in the sky than it is in winter when the Sun shines from a low position in the sky, that is more slantingly.

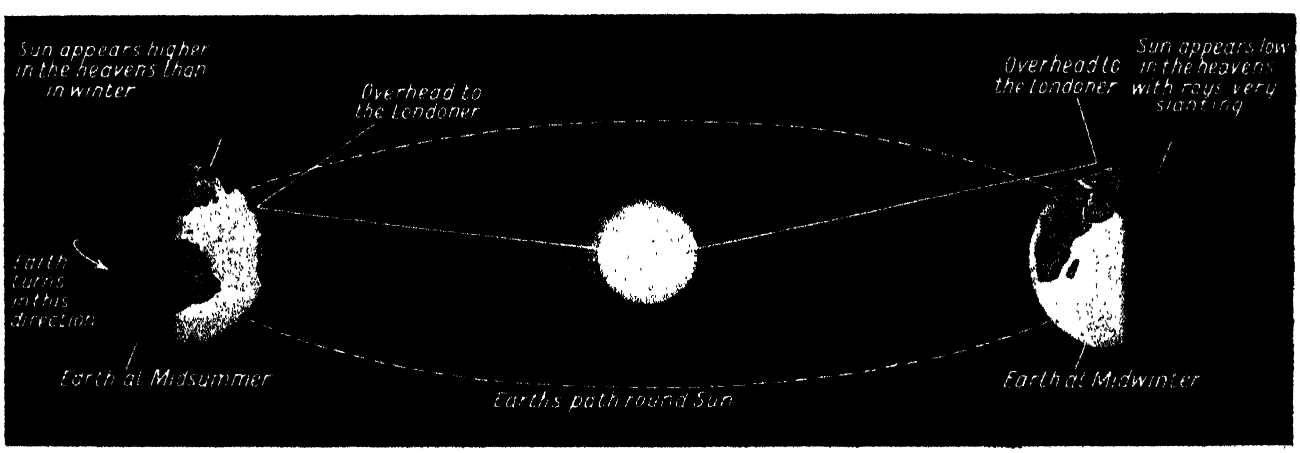
We can illustrate the movement of the Earth round the Sun by floating a rubber ball in a bath of water to represent the Sun, and using an apple for the Earth

It is this swinging north and south of the Sun's apparent path across the sky that causes the seasons. Were the axis of the Earth perpendicular to the plane of its orbit there would be no Spring, Summer, Autumn, or Winter, for the Sun would shine at exactly the same angle at every corresponding hour of every day throughout the year.

It is not our distance from the Sun that makes summer and winter, for as we have seen we are three million miles nearer the Sun in winter than we are in summer. The difference in the heat which we receive is due to the slant of the rays. The more directly they shine the hotter it is, and the more slantingly they shine the less heat they give to any particular point.

The Changing Spot of Light

We can prove this for ourselves by an experiment. Through a hole in a dark blind or shutter, let a ray of sunlight shine upon a sheet of paper, striking it at right angles. A round spot of light on the paper is the result. Now incline the paper, and instead of a round spot there will be an oval patch covering a larger area than when the paper was at right angles to the beam. But the



In this diagram we see on the left the Earth at the midsummer of the Northern Hemisphere, and on the right its position at midwinter in the Northern Hemisphere. The picture makes clear why in summer the Sun appears much more overhead to a Londoner than it does in winter. As can be seen, the angle between the zenith and the Sun is less at midsummer than at midwinter

patch is not only larger, but less bright as the angle is increased. It is evident why this should be so. The same amount of light has to cover a larger area the more slantingly the rays strikes the surface, and it is the same with any ray from the Sun striking the Earth. The more directly it shines the more concentrated is the heat and light.

The zenith is the point in the sky immediately over our heads, and the nearer the daily path of the Sun approaches the zenith the greater is its heating power, while as it recedes from the zenith its heat decreases

Unequal Shares of Sunshine

We can understand, too, that owing to the tilt of the Earth when the axis is pointing away from the Sun, as it is in winter, less than half the Northern Hemisphere is in the sunlight, but at the same time more than half the Southern Hemisphere is being shined upon. Then when the Earth has travelled round to the other side of its orbit and the South Pole is pointing away from the Sun, less than half the Southern Hemisphere is in the sunlight, while more than half the Northern Hemisphere is receiving light and heat rays. This is shown in the top picture on page 756.

We know the Earth's axis always points in the same direction whatever part of its orbit the Earth may be in; that is the axis always remains parallel to itself, for the North Pole always points to the Pole Star. The stars are, of course, such vast distances away that the mere change from the one side of the orbit to the other, a distance of only 186 million miles, makes no difference in their position so far as the Earth is concerned. We see the same stars above us from either side of the orbit.

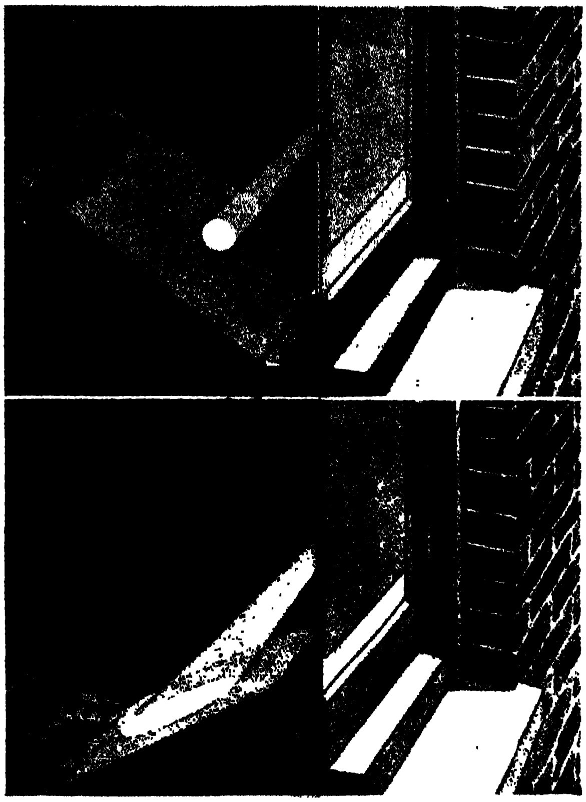
While it is true that so far as we are concerned, and during our lifetime, the Earth's axis is always tilted in the same direction, it has not always been so, nor will it always point in the same direction, that is towards the Pole Star. For the Earth as it spins round on its axis is something like a newly spun peg-top. We know how a peg-top not only rotates on its peg, but also slants or wobbles round so that its axis is constantly changing its direction.

Well, the Earth's axis is wobbling, if we may use that word, in the same way as the peg-top's. It is simply the wobbling of the great terrestrial top as it spins round on its axis that causes the tilt of the Earth. If the laws which govern the wobbling of the peg top were to cease to operate, the rotating Earth would spin round in an upright position, and then the time of year which is now our summer would be colder than the period which is now our winter. Men of science call this wobbling of the Earth on its axis the precession.

The Earth Wobbling Round

In about 12,000 years' time the axis of the Earth, instead of pointing in the direction of the Pole Star, will point towards the star Vega, the principal star in the constellation of Lyra. This happens to be the point in the heavens towards which the whole Solar System is moving. In other words, in about 12,000 years Vega will be the Pole Star, and Polaris, the present Pole Star, will be in a different part of the heavens relative to the Earth. In about 26,000 years the Earth's axis will have wobbled right round and will have returned to its present direction once more.

So far as any appreciable difference is concerned the axis in the lifetime of a living person remains in the same direction, yet there is a slight change going on all the time. In 12,000 years, when the axis points in the opposite direction from that in which it now points, the Northern Hemisphere will be directed away from the Sun at the time of year at which we now experience our summer.



When the Sun's rays fall slantingly they have to heat a greater area of the Earth's surface than when they fall direct Why this is we can prove by the simple experiment shown here. Through a hole in a dark blind we let a ray of sunlight shine upon a sheet of paper. If we hold the paper at right angles to the ray so that the light falls directly upon it the area covered by the ray is, can be seen, much smaller than when we hold the paper at an angle, so that the ray strikes it more slantingly, as shown in the lower picture

In this picture we see how in the Northern Hemisphere, in which the British Isles are situated, the Sun swings north in summer and south in winter. The result is that in its passage across the heavens it reaches a point much nearer overhead than it does in winter. Of course, the sun is never directly overhead except at certain seasons in the Tropics

A GREAT STAR CLOUD IN THE MILKY WAY

This photograph, given by courtesy of the Mount Wilson Observatory, U.S.A., shows part of the great star cloud in the constellation Sagittarius. This cloud is not a distant universe, but is really the brightest part of the Milky Way. Astronomers believe that the whole of the Milky Way which we see going round the heavens as a faint band of light is moving round like a wheel round a hub. It is the rotation that prevents all the stars at the rim being drawn into the hub by gravitation. Sir James Jeans explains that we should expect to see the greatest number of stars by looking in the direction of the hub to the rim beyond, and as a matter of fact this great star cloud in Sagittarius is near the hub of the great Milky Way wheel. Sir James Jeans says that travelling at 200 miles a second our Sun, with its family of worlds, probably takes two or three hundred million years to make a complete journey round the hub

WONDERS OF THE SKY

STAR CLOUDS AND STAR CLUSTERS

The wonders of the heavens become greater the more our knowledge increases, and in these pages we read some marvellous facts that men have discovered about clouds and clusters of stars that are many thousands of light-years away from us. These discoveries are of comparatively recent date

FOR convenience of reference men have from the most ancient times grouped the stars together into what are known as constellations If every star in the heavens were regarded as an isolated unit it would be very difficult to refer quickly to a star, but by reckoning them in definite groups and numbering or naming them in those groups, it is quite easy to refer to any particular star or to find it if it is mentioned

But in addition to the groups or constellations, there are other collections of stars which appear still closer together in the heavens. Some of these were known to the Ancients including one group, consisting of seven principal stars to be seen in the constellation of Taurus, or The Bull. It is called the Pleiades.

The name comes from a Greek word meaning to sail, and it was given to this group of stars because their rising above the horizon indicated the time of safe navigation The cluster appears on the eastern horizon in September, and is on the meridian at midnight in November. It then passes across the heavens and disappears below the horizon at the end of March to reappear low down on the horizon in July.

Not more than six of the stars in the Pleiades can be seen easily with the naked eye to-day, although some very keen-sighted people can see seven, but in ancient times apparently seven stars were clearly seen

Although only six or seven stars can be seen in the Pleiades group with the naked eye, when photography and a large telescope are utilised as many as 2,326 stars can be counted, and some of the stars seem to be wrapped in masses of nebulous matter. The group to the naked eye is only a dot in the sky, but actually it occupies an immense space so that light, which travels at 186,000 miles per second, would take eight years to cross from one side to the other. It takes about 250 years for the light of its central star Alcyone to reach the Earth.

There is a definite reason for thinking that the stars of the Pleiades really form one group, for they seem to be travelling in the same direction.

But in addition to groups of this kind, the large telescopes have revealed other groups of stars far more immense. Nearly all of these are invisible to the naked eye, but one or two can be discerned, and one is visible to the unaided sight even when the full moon is shining.

Two such groups are known as the Greater and Lesser Magellanic Clouds, and are to be seen in the southern skies Through a telescope of moderate size they appear as cloudy films of light, but examination through a large telescope has shown that these so-called clouds are composed of myriads of stars, many of them grouped in clusters, and they are now believed to be what astronomers call Island Universes, that is they are universes like that of the Milky Way to which our solar system belongs, and are right outside the Milky Way system; in fact they are now believed to be more than 100,000 light-years distant, or to put it in figures, 5,870,000,000,000,000,000 miles

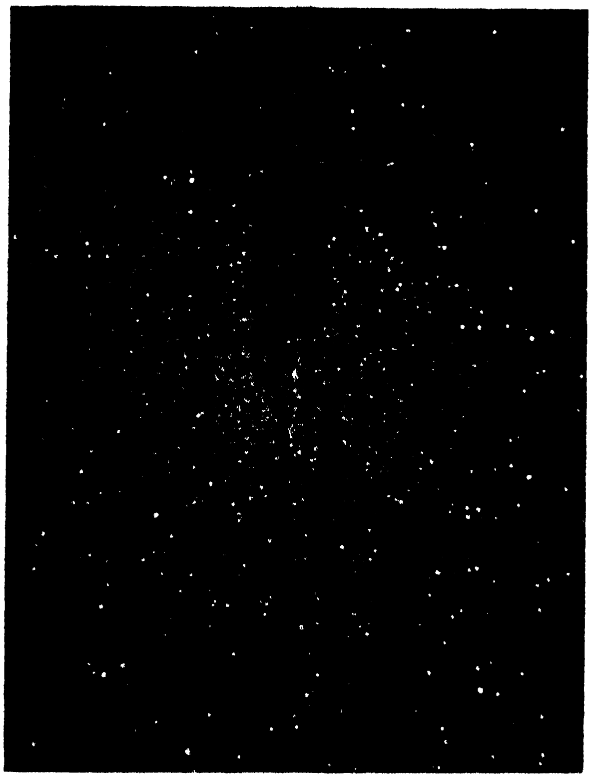
The lesser Magellanic Cloud appears in the constellation Tucana near the South Pole, and it is so vast that light takes 6,000 years to pass from one end of it to the other. It contains at least half a million stars brighter than Sirius, the Dog Star, the principal star in the constellation Canis Major, and the brightest star in the heavens But in addition there are myriads of other fainter stars.

Besides these star clouds there are also what astronomers describe as star clusters These are groups of stars in which a number of stars appear clustered together and seem to have some common form of motion There are two kinds of clusters. Some are called open clusters, and the Pleiades is one of this kind

But the more remarkable of the star clusters are those which are known as Globular Clusters because of their apparent shape. About 69 of these have been detected An example of the globular clusters is the great star cluster in the constellation of Hercules. It is No 13 in the list or catalogue made out by the astronomer Messier, and so is usually spoken of by astronomers as M.13. While the open clusters are part of our Milky Way system, the globular clusters are independent collections outside of our system.

It is very difficult to count the number of stars in a globular cluster, as may be gathered from the photograph on this page of the cluster in Hercules, and the difficulty is increased by the fact that the longer the exposure more and more stars appear on the photograph. In the group M.13, the number of stars is probably at least 100,000.

Some of these globular clusters are to be seen in photographs of the star clouds. Two such can be seen in the



A great globular cluster of stars called by astronomers M.13, in the constellation of Hercules. It is the most splendid of all the clusters that are to be seen from the Southern Hemisphere. It is only just visible to the naked eye, and yet it throws out two and a half million times as much light as the Sun. It is, however, so immensely distant that its light travelling at 186,000 miles per second takes 33,000 years to reach us. This photograph is given by courtesy of the Royal Astronomical Society

top left-hand part of the Lesser Magellanic cloud on this page One of these is the nearest and brightest of all the globular clusters, and is only about 20,000 light-years away from us.

One very interesting thing about the star clusters is that in them are found stars which vary periodically in brightness. Some stars that vary in brilliance are called Eclipsing Binaries, and the explanation of their variation is believed to be that they are not one star but two. The change in their brilliance is due to the fact that they go round one another, and at intervals the brighter is eclipsed by the other star passing between it and us.

But there is another kind of variable star which is known as a Cepheid Variable, from a typical member of its theory has been elaborated by the famous Cambridge astronomer, Sir Arthur Eddington.

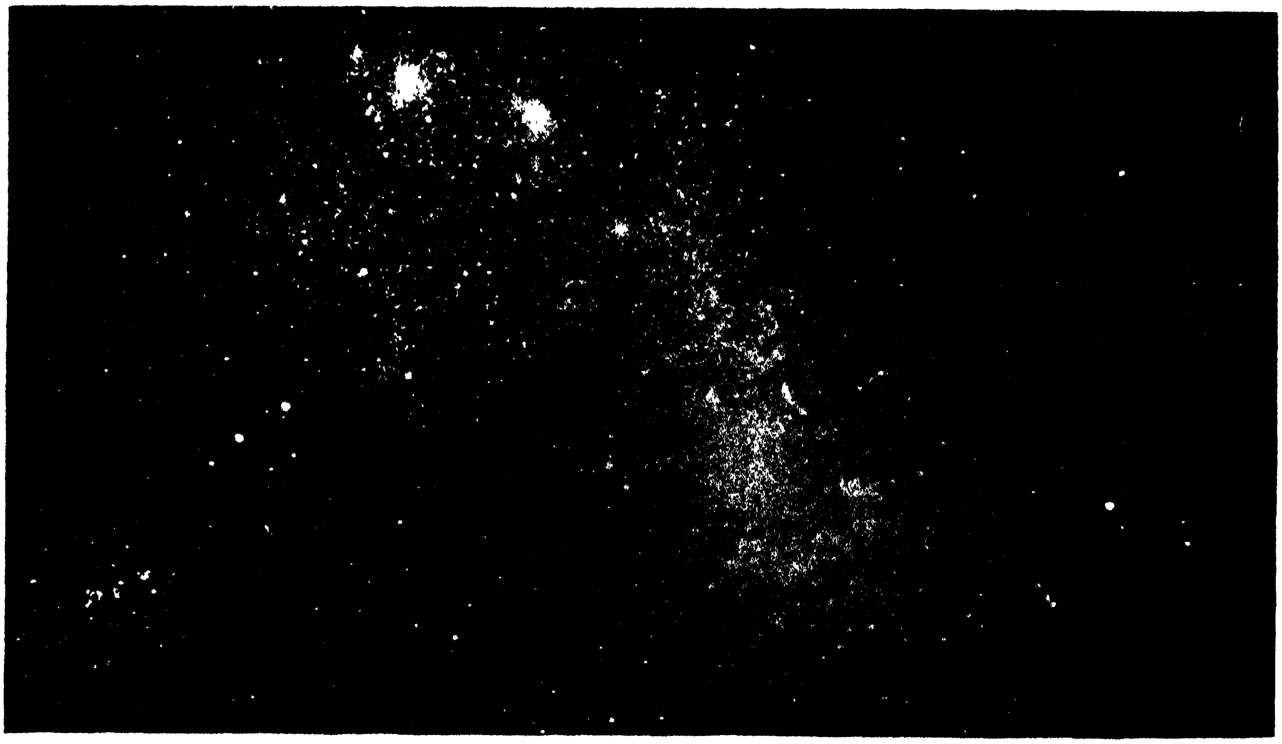
There is, however, another theory suggested by Sir J. H. Jeans, who imagines that the Cepheid variables are in shape ellipsoids, that is, solids with an elliptical outline. He thinks these stars are rotating rapidly about the smaller diameter, so that alternately the long view and then the short view is presented to us. Sir J. H. Jeans believes that this stage of a variable star is an earlier form than the eclipsing binaries. In other words, the Cepheid or Cluster variable is an elliptical star which is about to break up into two stars, when it will have reached the binary stage that has already been described.

We must wait for further knowledge

clusters are distant from us more than 100,000 light-years, and the most distant are calculated to be 200,000 light-years away.

One very interesting fact in connection with these star clusters is that of the 69 which have been found and examined, 32 are north of the plane of the Milky Way, and 37 south of it. The centre of the system of clusters appears to lie in the Milky Way in the neighbourhood of the dense star clouds of Sagittarius.

Another very interesting fact discovered by Dr. Harlow Shapley of Mount Wilson Observatory, who has devoted much care and time to the examination of star clusters, is that there is a belt between ten and twelve thousand light-years wide, in which



The Lesser Magellanic Cloud, which is visible to the naked eye near the south pole of the heavens and can therefore be seen only in the Southern Hemisphere. It is so vast that light takes 6,000 years to pass from one end to the other. There are millions of stars in this area of which half a million are brighter than Sirius, the brightest of all the stars visible from the Earth. This photograph was taken at the Boyden Station of the Harvard College Observatory in Arequipa, Peru, and is given here by courtesy of the Observatory

class in the constellation Cepheus. This star, from its faintest appearance, increases in brilliance and then decreases once more, the total period being nearly five days and a half. The variable stars in the star clusters, however, generally complete their periods of variation in less than a day, and they are sometimes called Cluster variables.

Now the variation in the Cepheid and Cluster variables is not due to one star being eclipsed by another. It is believed to be due to pulsating, the star alternately expanding and then contracting. The reasons for believing this are far too difficult and mathematical to be gone into here. The

to be sure which, if either, solution of the problem is the right one.

In addition to these variable stars the clusters contain various other kinds of stars, some of them being deep red, of the type of the giant red stars, like Antares and Betelgeux, while others are blue-white, of the type of Vega and Rigel. The brightest stars in the globular clusters have been found by astronomers to have a surface temperature two or three thousand degrees less than that of our Sun, and they are much redder in colour than the Sun. The blue-white stars are two or three magnitudes fainter than the brightest red stars.

One quarter of the globular star

no globular clusters at all are to be found. Within this belt are nearly all the stars which have been placed in the star catalogues, including the stars visible to the naked eye, and the gaseous nebulae, together with the open star clusters. The explanation that is given by astronomers of the absence of globular clusters within this belt is that they are unable to form and go on existing in a field where gravitation is so powerful.

The discoveries of the star clouds and star clusters with their immense sizes and distances have surprised even astronomers, and dealing as they are with the vastness of Space, it takes a good deal to surprise an astronomer.

WONDERFUL THINGS ABOUT OUR HAIR

We are told that a woman's hair is her glory, and this is almost as true in the case of a man, for any man or woman without hair would look very strange indeed. How curious it is that, although we comb and brush our hair every day, wash it every week, and have it cut or trimmed every two or three weeks, and although many of us spend quite a large sum in having our hair waved or otherwise attended to by the hairdresser, few of us really know much about the hair and how it grows. Here are many interesting facts about our hair

When we speak of hair we generally think of the hair of the head. But this is not the only place where hair grows. It is found all over the human body, except on the palms of the hands, the soles of the feet, the surface of the eyelids, and one or two other places

The hair, however, is different in different parts of the body On the head we have long soft hairs and all over our skins soft downy hairs. Along the edges of the eyelids and in the nostrils there are short stiff hairs

There is a verse in the Bible which says " the very hairs of your head are all numbered," and this is perfectly true. Men of science have counted the hairs on the heads of many people, and the number is about a hundred thousand

In animals, of course, the hair is a useful covering, and possibly it was the same for human beings at one time, for the fine hairs of the body and limbs of men are arranged in the same way as in the monkey. They point in certain directions, so as to allow the rain to shoot off from the body when the animal is climbing. Nowadays, however, the hair is chiefly an ornament in human beings.

Hair is really formed in very much the same way as the nails Hairs are

This is an unusual sight, for nowadays not many women or girls wear their hair long. Yet there is something very beautiful about a really fine head of hair, as we can see in this picture

modified parts of the skin, just as nails are The horny layer of the epidermis or outer skin becomes thickened and forms the nails, and in the same way the hair is composed of horny cells developed from the cells of the epidermis.

What really happens is this: as a child grows up the epidermis every here and there grows down into the dermis or true skin, that is, the under layer of skin, and forms a solid mass of cells known as a hair-follicle "Follicle" simply means "a little bag"

Then into the bottom of this follicle or bag the fibrous tissue of the true skin rises and forms a small projection or eminence The sides of the follicle become surrounded with a thickened layer of tissue and then the cells at the top of the eminence begin to multiply, those below pushing up those above till they form a kind of shaft.

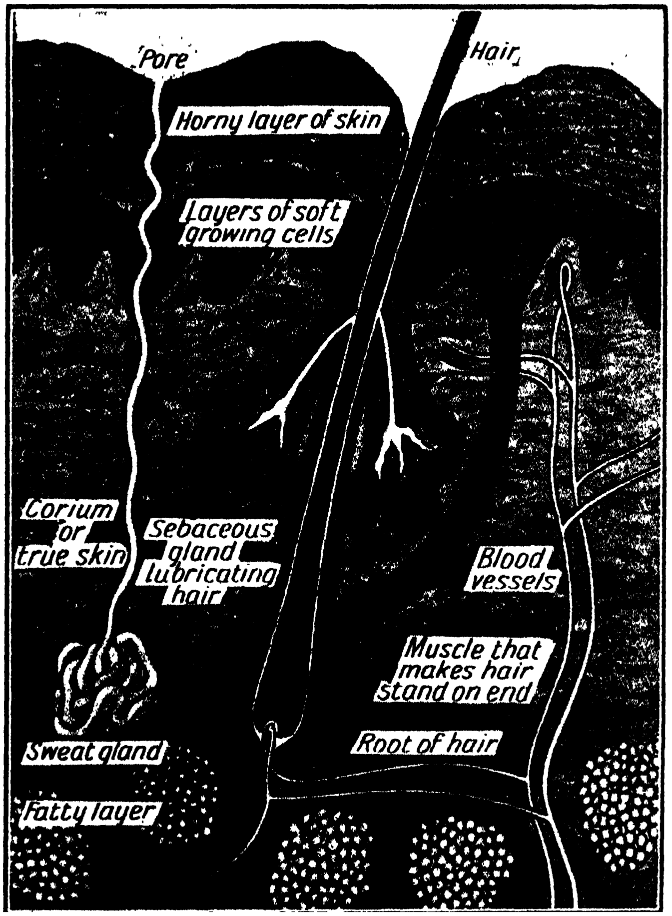
How Hair Grows

This increases in length and begins to project from the skin It is a hair, and as the cells at the base go on multiplying, the hair gets longer and longer, till in the case of the hair of the head, if left uncut, it will grow to a great length Eventually, after it has reached a certain length, the base ceases to grow, and the eminence from which the hair sprouted and the little bag in which it is enclosed die away and the hair is shed. But before this happens a new bag or follicle, sometimes called a sac, and a new eminence or projection (called by men of science a papilla) has been formed. From this a new hair at once begins to rise.

A hair is thus a horny shaft growing out of a little bag buried in the skin, and this shaft is only about one 400th of an inch in diameter. If it is split and placed under a microscope we can see that there is a pithy canal up the middle which is surrounded by the horny substance, and then right outside is a kind of skin covering This is made up of a layer of cells which overlap one another like the tiles of a roof

As a proof of this tile-like arrangement we can perform an interesting and rather amusing experiment upon one of our own hairs pulled from the head. Hold the hair in the middle between the thumb and finger, and then work the thumb and finger to and fro. We shall find that the scalp or root end of the hair always moves away from the thumb and finger, while the other end moves towards them The tile-like arrangement of the scales causes this action which is something like a ratchet movement. If you have a hair and do not know which is the root end, you can always discover it in this way

The hair is fed by blood vessels at the root and it is lubricated by little fat glands known to science as sebaceous glands, from the Latin word "sebum," meaning "tallow." These sebaceous glands are distributed all over the surface of the skin wherever there are hair-follicles, and little channels open from them into the follicles. The gland itself is made up of a mass of cells.



How the hair grows with its roots in a little bag in the skin, a blood vessel to feed it, a fat gland to lubricate it, and a muscle to make it stand on end. The nerves are not shown

The hair-follicle or bag always lies slantingly to the surface of the skin, so that the hairs as they grow, instead of standing up straight, lie over to one side.

It might be asked why when people get a fright their hair sometimes stands on end. This is very marked in certain individuals, whose flesh owing to fear is covered all over with little white projections which we call goose-flesh The hair of the cat or dog stands up on end when the animal is angry or on the defensive.

Well, each hair follicle has attached to it a little muscle which is known as the arrector pili. This looks a difficult name, but it simply means "the hair raiser." When we get a sudden fright a message goes from our brain telling these muscles to work and make the hair stand upright. Of course, this serves no useful purpose in human beings, but when an animal like a cat is covered all over with hairs and they all stand up on end, it makes the animal look much bigger and fiercer, and so tends to frighten the foe

The hair has a certain amount of pigment or colouring matter in it in the form of little grains or granules, which accounts for its colour. In some this is much darker and there is more of it than in others Some children, however, are born without any pigment, and then we call them albinos, a word that comes from the Latin word "albus," meaning "white."

Why Hair Turns White

When a person becomes old his or her hair generally turns grey or white. This is due to the fact that the pigment granules are no longer formed and bubbles of air collect between the cells in the substance of the hairs. This causes the light to be reflected and to give a grey or white appearance. The more air bubbles there are in the hair the whiter or more silvery it appears.

Sometimes a great shock or fright will cause a person's hair to turn completely white in a single night. The reason for this cannot be explained, but it is nevertheless a well authenticated fact.

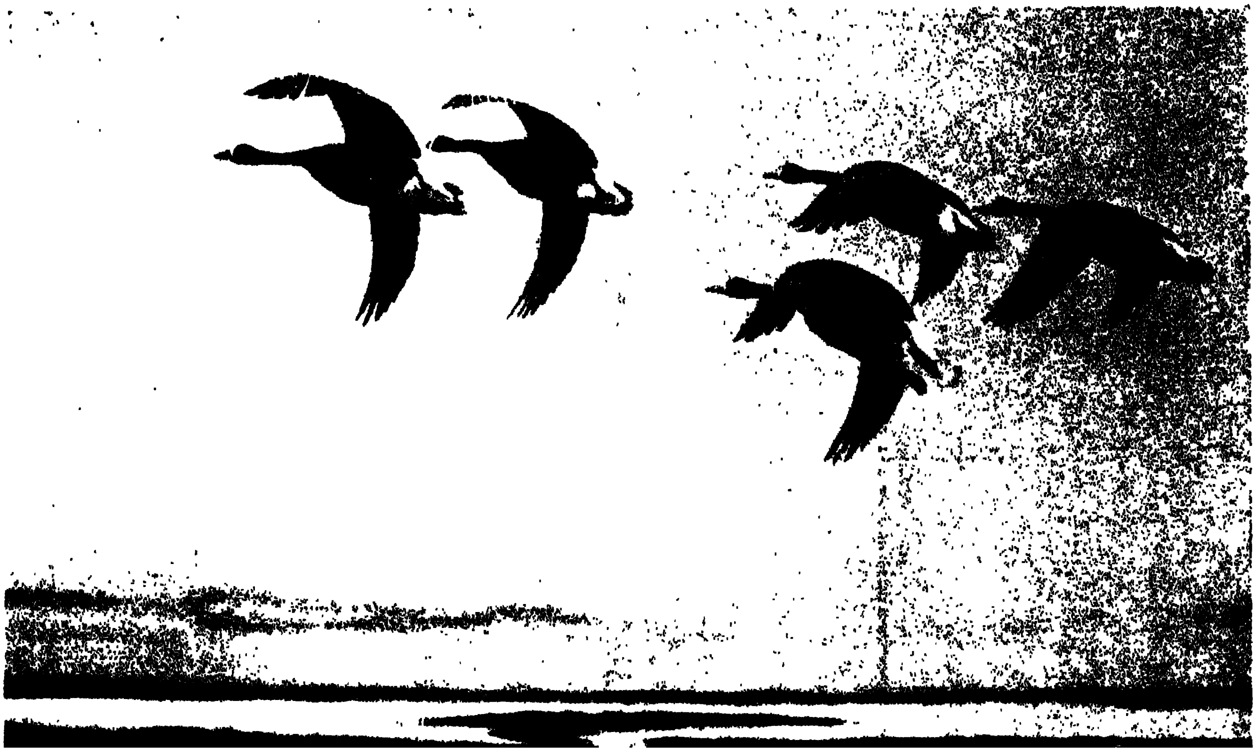
The hair is elastic, and stretches to one-third of its length. It is also very strong, for four human hairs will sustain a pound weight. Sometimes, when Eastern potentates wanted a very strong rope they used to have one made of women's hair. The hair, unlike flesh, when it is dead does not easily decay In the damp it will always take up a great deal of moisture.

The so-called woolly hair of the negro races is no more woolly than is the white man's The negro's hair is spirally curled, and is matted together in tufts. It is much coarser than the hair of the white races.

WHAT HAPPENS WHEN WE COMB OUR HAIR

When we comb our hair rapidly with a vulcanite comb we generate electricity, and some people, in the dark, can see quite a shower of sparks coming from their hair. What really happens is that by the action of combing we are taking electrons out of the atoms, or adding them to the atoms. It is the passing of the electrons that causes the apparent sparks that we see in the dark. If we listen carefully we shall hear the crackling of the sparks which corresponds on a small scale to the clap of thunder that accompanies lightning. These girls at camp are listening for the crackling, which in some people is much more marked than in others

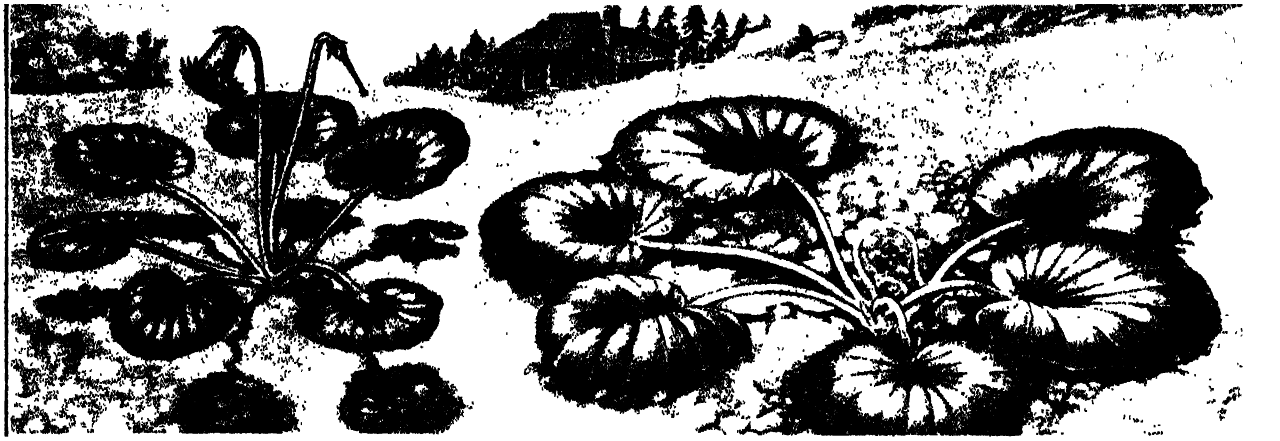
WILD GEESE AND DUCKS IN FLIGHT



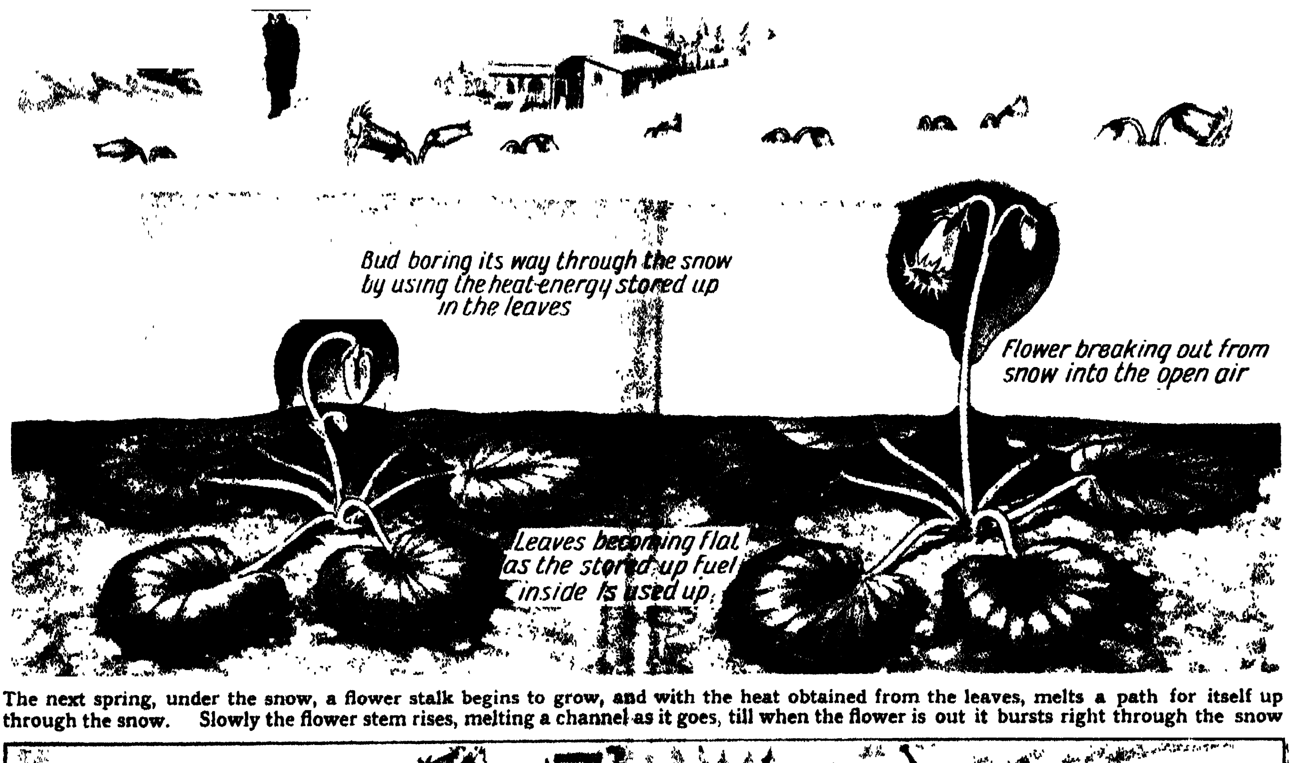
This painting by the well-known bird artist Mr. Roland Green shows how the white-fronted geese fly in wedge form with necks outstretched. They breed in Lapland and Arctic Siberia and visit the British Isles in winter, where they are seen in fenny districts and are more common in Ireland than elsewhere. The most prominent feature of this goose is its white forehead. As it flies it makes a curious laughing sound like "ha-ha" several times repeated, and this can be heard at a considerable distance

Here Mr. Green shows the sheld-duck's flight, which is much like that of the goose. The bird keeps its neck outstretched and it is interesting to know that it is regarded by scientists as a link between the geese and the ducks proper. The word sheld means piebald or parti-coloured a reference to the plumage of the bird with its black and white and brown and green

A PLANT THAT BORES A WAY THROUGH ICE



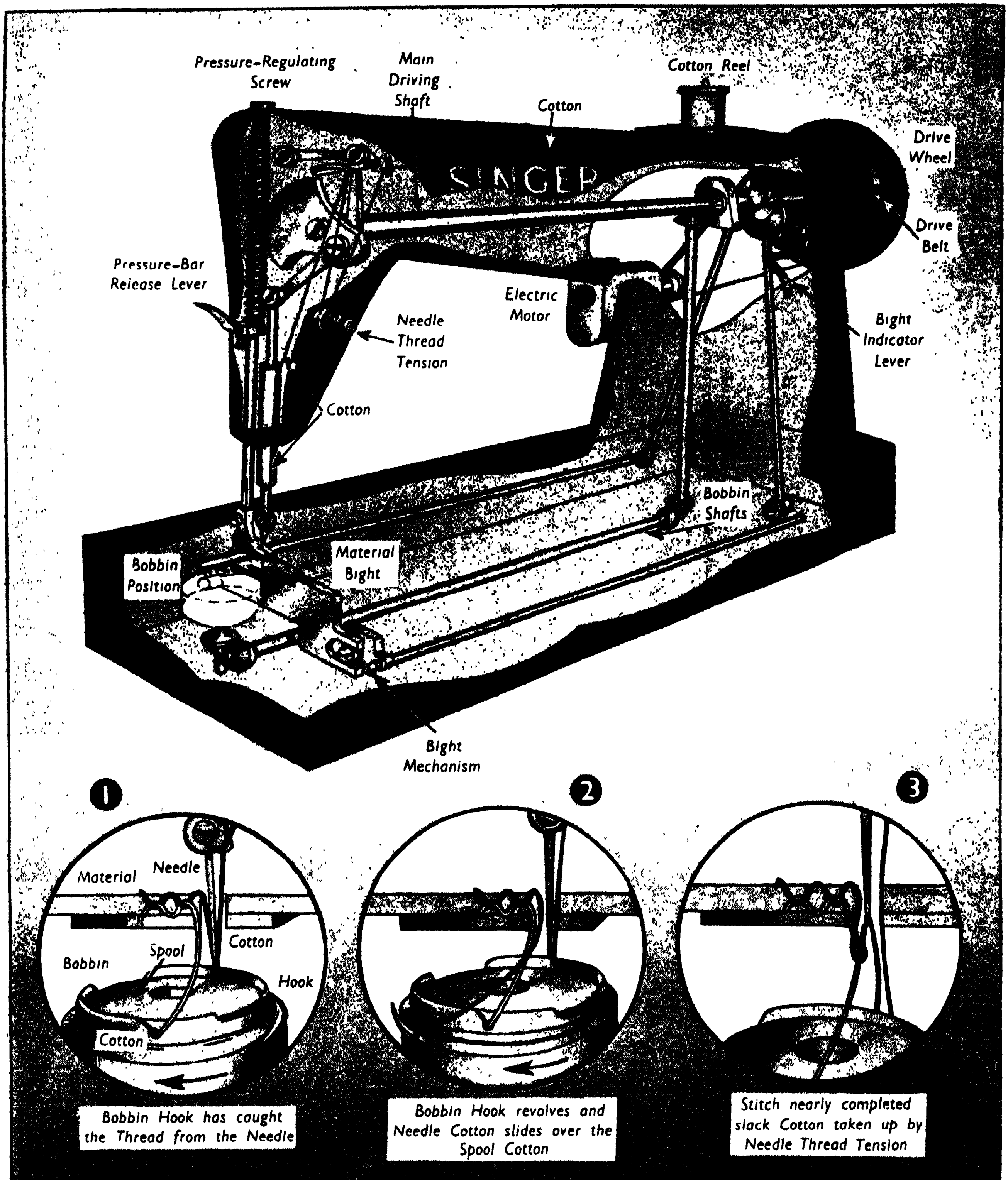
The little Alpine plant shown here, called soldanella, has the wonderful power of boring a path for itself through snow and ice into the light. On the left we see the plant with its leaves and flowers as it appears in spring. As winter approaches after flowers and seeds have gone, the plant takes up much nourishment and stores this up in its leaves, which become quite thick, as shown on the right



The next spring, under the snow, a flower stalk begins to grow, and with the heat obtained from the leaves, melts a path for itself up through the snow. Slowly the flower stem rises, melting a channel as it goes, till when the flower is out it bursts right through the snow

By this time the thick leaves have become thin, their stored nourishment having been used up. When the snows have disappeared, insects fertilise the soldanella blossoms, as shown on the left, and the plant then produces seed heads as seen on the right

HOW A SEWING MACHINE DOES NEEDLEWORK



The main shaft works a second system of levers, which causes the bobbin to swing to and fro and supply the cotton that makes the stitch in conjunction with the needle. A third lever movement supplies the cotton to the needle from the reel on top. The needle has a separate supply of cotton from the bobbin. The bobbin's supply is inside it on a little metal reel, and the cotton can be drawn through the side of the shuttle as required. A wheel on the end of the main shaft as it turns round raises and lowers an upright rod, on which is the needle. The up-and-down movement is obtained by means of a small projection on the wheel. By comparing the three lower pictures we can see how the sewing-machine operates. When the needle penetrates the material, carrying its cotton with it, the bobbin passes through the loop of needle cotton, and when it is right through the needle ascends, catching up the bobbin cotton and drawing both cottons tight. The bobbin then returns ready for the next operation. The tension of the needle can be adjusted according to the thickness of the material to be sewn. There is also a thumbscrew for adjusting the tension of the thread.

THE STORY OF THE SEWING-MACHINE

Few mechanical devices have proved more useful in the home than the sewing-machine. Even in these days, when clothes are so often bought ready-made, there are few homes without a sewing-machine worked either by hand, treadle, or electric motor. The story of the sewing-machine is told on this page

Not only in the home, but in the factory, the sewing-machine is a great boon. A clothing factory or a boot factory could not run without its sewing-machines.

Yet the sewing-machine as a practical device is little more than a century old. A sewing-machine for use in the making of boots and shoes had been patented as far back as 1790 by one Thomas Saint, but he tried to make his machine work on a wrong principle. He endeavoured to imitate the ordinary sewing by hand in which a needle with a thread is pushed completely through the material. This process does not lend itself to mechanical reproduction, for the human hand moves through a very great distance in proportion to the amount of work done.

It was a poor French tailor named Barthélemy Thimonnier who made the first sewing-machine that would really work. But it was constructed almost entirely of wood, and was too clumsy to do much work. However, it was considered good enough for a number of similar machines to be made, and it is said that in 1841 there were as many as eighty of these being used in Paris.

Then the ignorant workmen became alarmed, believing that they would lose their jobs, and so they smashed up the machines and nearly murdered the inventor.

At the Great Exhibition

Later Thimonnier improved his invention, took out patents in England, and made a model of metal. A specimen of the machine was shown at the Great Exhibition of 1851, but nobody seemed interested, and poor Thimonnier died in want a few years later.

The great thing that made the sewing-machine a real success was the invention of a needle with an eye in the point. This was first thought of by Walter Hunt of New York, somewhere about 1834. He then made a sewing-machine, using one of his needles, which carried a loop of thread through the material and then had a shuttle passing through the loop underneath, thus making a lock stitch.

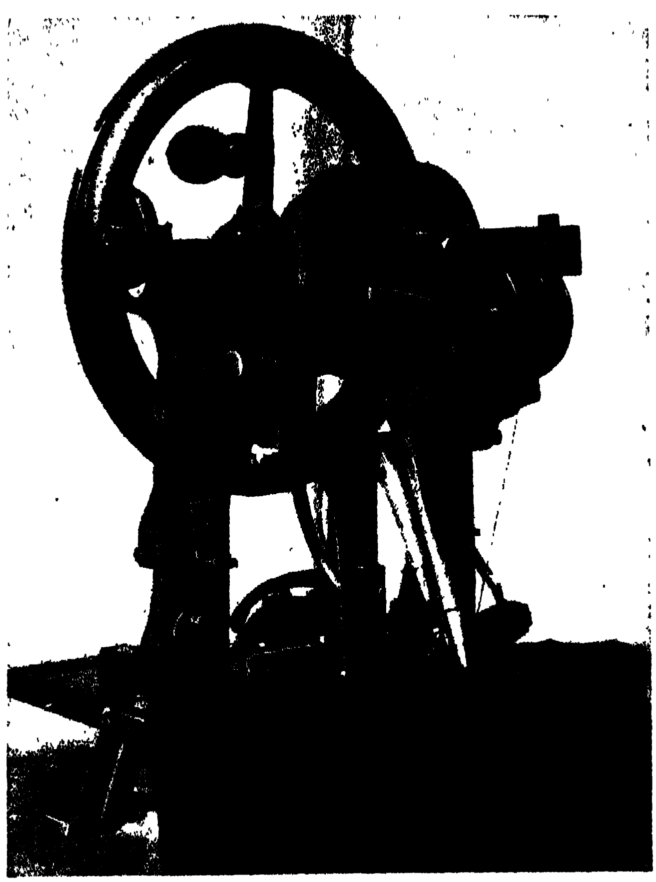
But nothing came of the invention, and it was left to Elias Howe, a native of Massachusetts, to patent the first really practicable sewing-machine. This earliest machine is to be seen in the Science Museum in London, and a photograph of it is given on this page.

It was patented in 1846 and employed an eye-pointed needle and a shuttle. The invention was sold to a London manufacturer for £250, but Howe, like so many inventors, made little out of his invention and returned to America a poor man.

Then in 1851, the year of the Great Exhibition, Isaac Singer obtained a patent for a sewing-machine which was very much on the lines of machines as they are made to-day. But Howe had determined to stand up for his rights, and he began various law actions. Cases were fought in the English and American courts over a long period, and at last Elias Howe won the day, and received royalties on all sewing-machines until his patent ran out in 1867. He died shortly afterwards, but there had been an extraordinary change in his fortunes from the time when he went back to America a poor man, for it is said that he received in royalties no less than £400,000.

After that many improvements were made and different shuttle devices invented. Thousands of patents have been taken out both in the United States and in European countries in connection with these sewing-machine improvements.

The main principle of the sewing-machine, however, remains the same as that devised by Elias Howe, although different machines make different stitches. Some will make a chain-stitch, others a double chain stitch, and others again a lock-stitch.



The original sewing-machine of Elias Howe, which is now to be seen in the Science Museum at South Kensington. This photograph is reproduced by courtesy of the Director of the Science Museum

Sewing-machines are produced for all kinds of industries. For working stout leather, for instance, a very strong form of machine is needed, and a great step forward was taken when an adaptation was made which enabled the soles to be sewn on to the uppers of boots by machine.

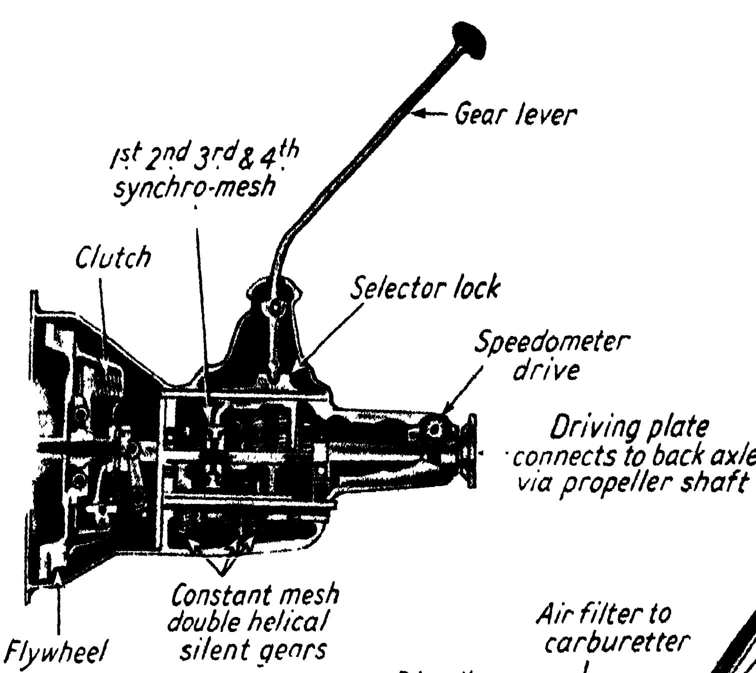
Machine-Sewn Boots

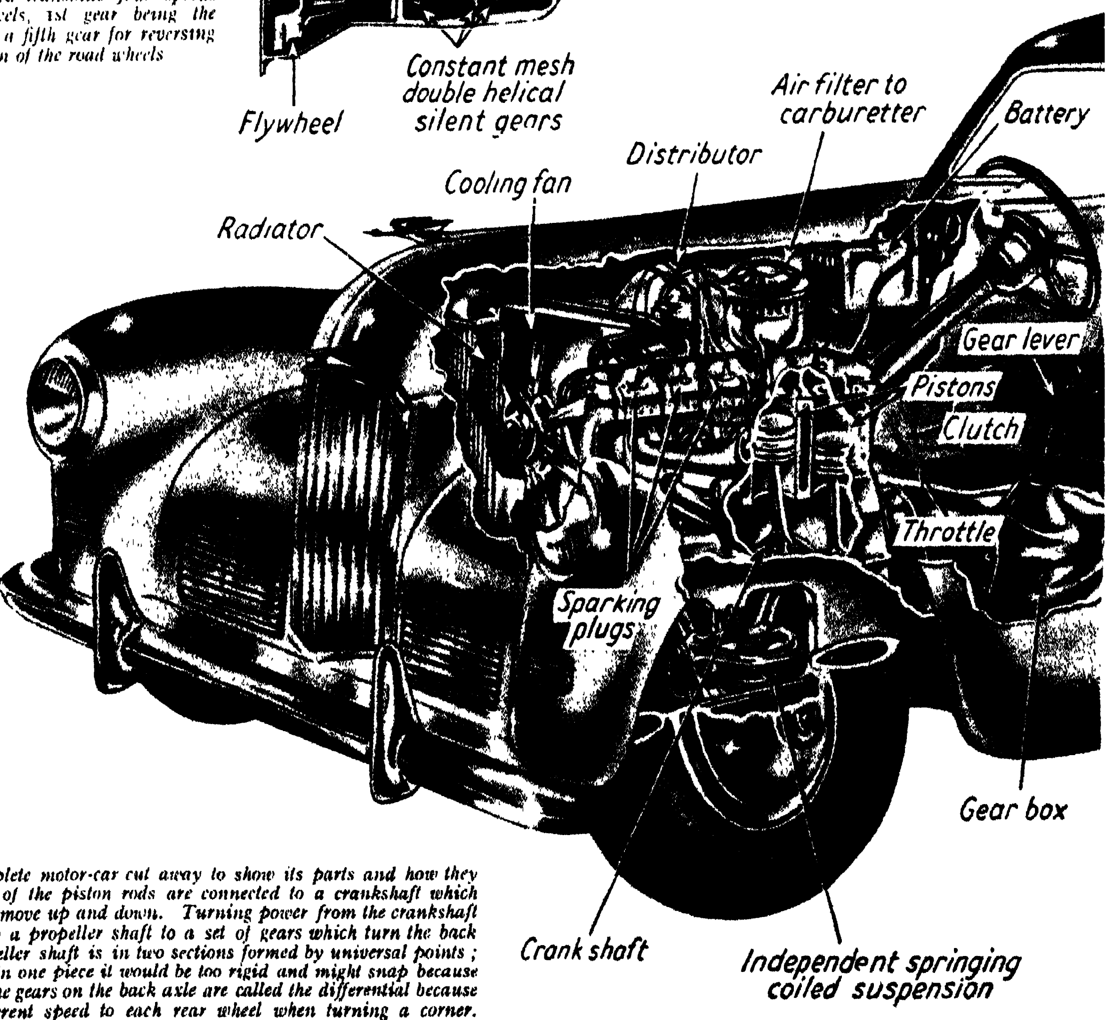
Now the great mass of the hundreds of millions of boots that are made have their soles sewn on by a sole-sewing machine, which uses a waxed thread. The hand-sewn boot and shoe has now become rare, although there are still a few workers who can make hand-sewn footwear, which is, of course, much more expensive.

It is no exaggeration to say that the boot and shoe industry has been completely revolutionised by the sewing machine.

Sewing-machines are used for making buttonholes, and they can work ten holes a minute, while others can fasten on buttons. Not only clothes and boots and shoes, but gloves, umbrellas, carpets, and so on are all now made by sewing-machines.

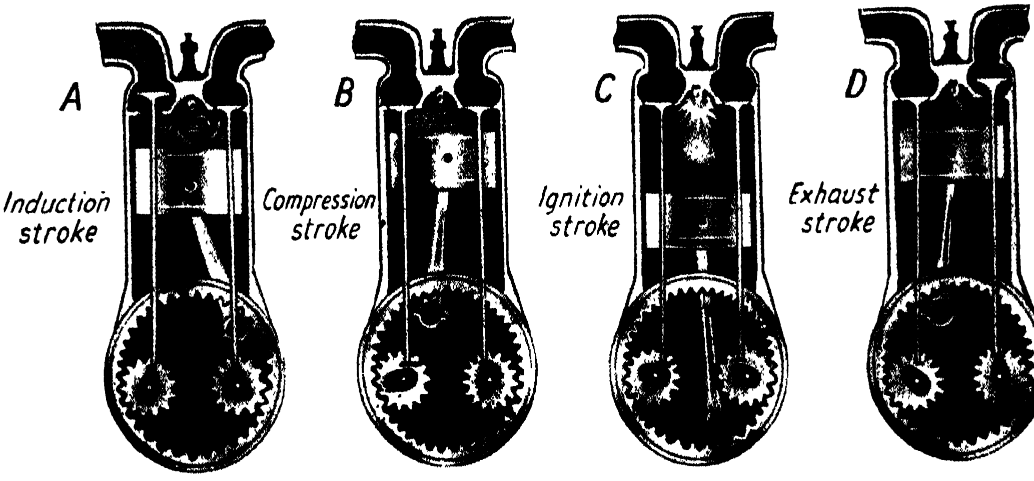
The diagram on the right shows the inside of a motor-car's gearbox. Petrol engines have very little power at low speeds, and if the engine were always connected through the clutch directly to the driving shaft it would be impossible to start easily, to travel slowly in heavy traffic, or reduce speed when taking corners. Gears are based on the principle that if a large cog wheel and a small cog wheel are engaged, and if the large wheel has twice as many teeth as the small one, the large wheel makes only one turn while the small one turns twice. Motor-car gears are so arranged that while the engine turns at a constant speed its power is connected to the driving shaft by large to small gears for high speed of the road wheels, and by small to large gears to lower the road speed. In driving slowly, which means changing the gears through the gear lever so that there is a small wheel on the engine shaft and a bigger one on the driving shaft, the effort of the engine is applied gradually and with force. The gearbox illustrated transmits four speeds to the road wheels, 1st gear being the slowest; there is a fifth gear for reversing the direction of the road wheels



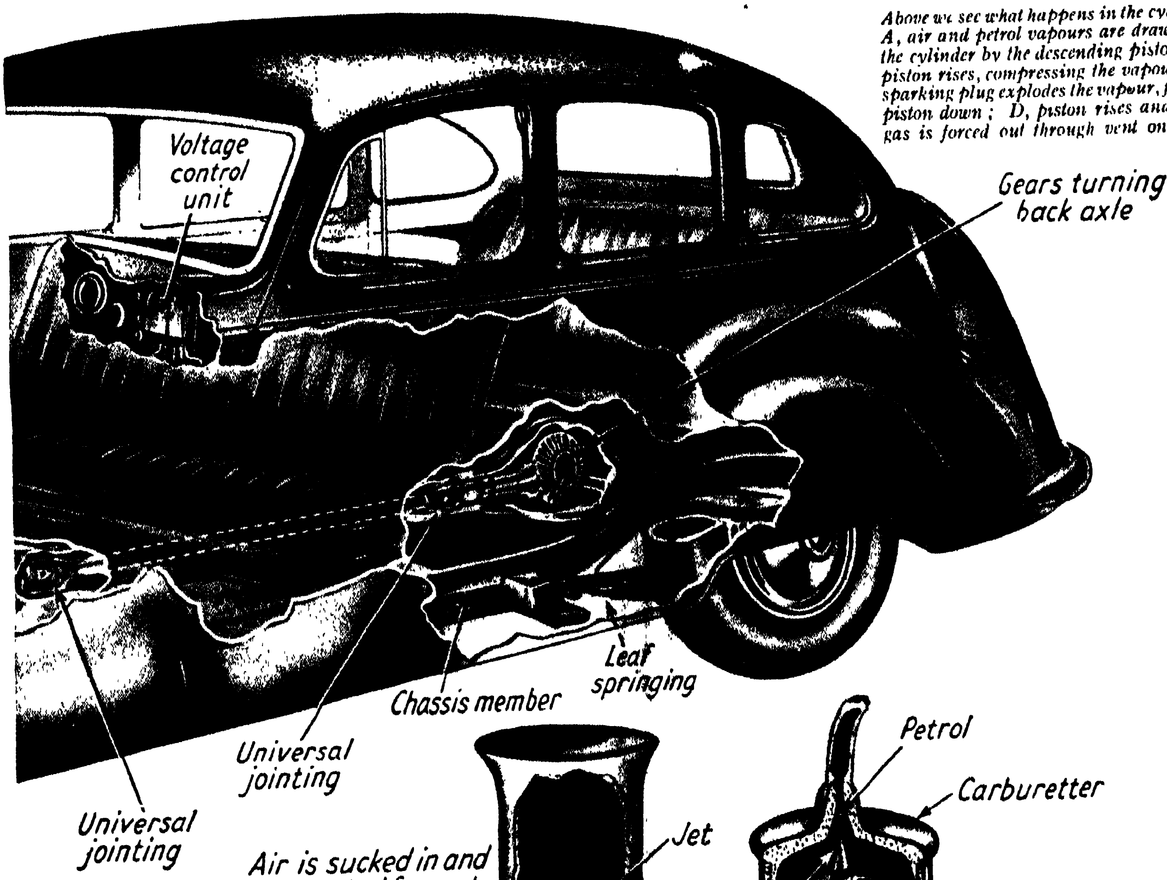


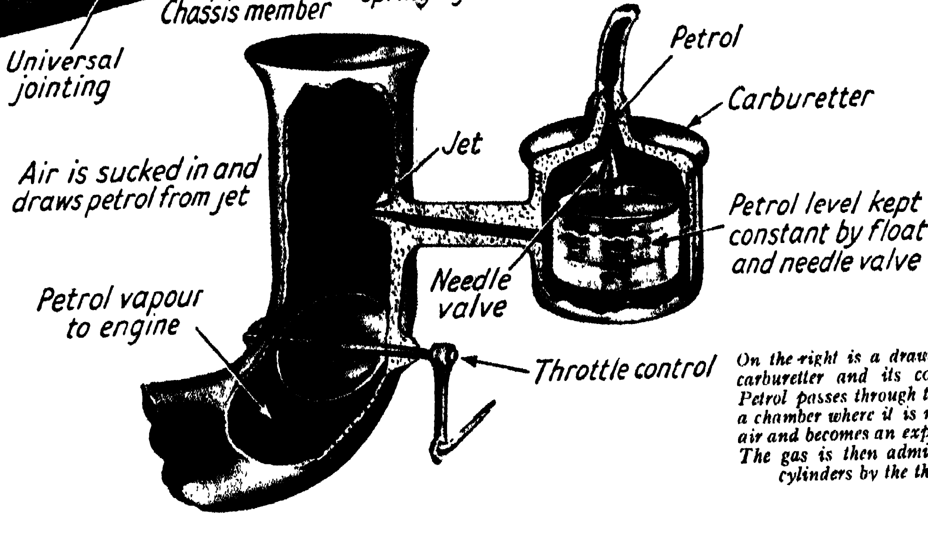
Here is the complete motor-car cut away to show its parts and how they work. The end of the piston rods are connected to a crankshaft which they turn as they move up and down. Turning power from the crankshaft is transmitted by a propeller shaft to a set of gears which turn the back axle. The propeller shaft is in two sections formed by universal points; if the shaft was in one piece it would be too rigid and might snap because of vibration. The gears on the back axle are called the differential because they give a different speed to each rear wheel when turning a corner. When the car turns to right, the right hand rear wheel must travel faster and the left hand rear wheel, having a shorter distance to travel, must move more slowly. Other parts shown on the drawing are the sparking plugs, which explode the mixture of air and petrol in the cylinders; the distributor, which fixes the order in which the plugs spark; the throttle, which controls the amount of petrol vapour to the cylinders; the clutch, which through the gearbox holds the driving shaft against the crankshaft; the air filter through which air passes to be mixed with petrol to supply vapour for the cylinder; and the battery, supplying current to the sparking plugs.

In this picture diagram, which runs across two pages, we see the inside of those parts of a motor-car usually hidden by the bodywork. In some types of car the engine is mounted over the back axle, but the arrangement shown here is the most common. The smaller



Above we see what happens in the cylinder. A, air and petrol vapours are drawn into the cylinder by the descending piston; B, piston rises, compressing the vapour; C, sparking plug explodes the vapour, forcing piston down; D, piston rises and waste gas is forced out through vent on right.

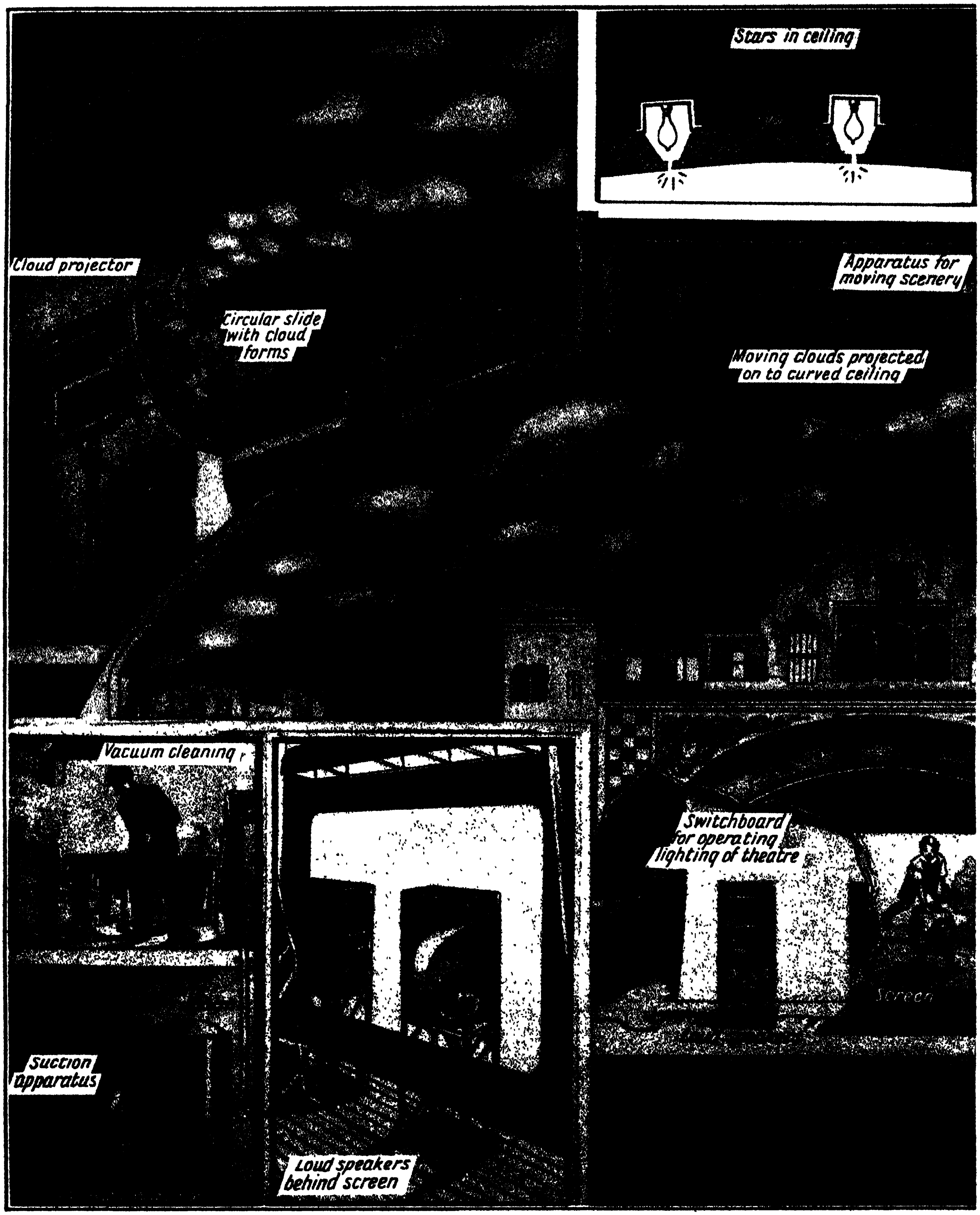




On the right is a drawing of the carburetter and its connections. Petrol passes through the jet into a chamber where it is mixed with air and becomes an explosive gas. The gas is then admitted to the cylinders by the throttle.

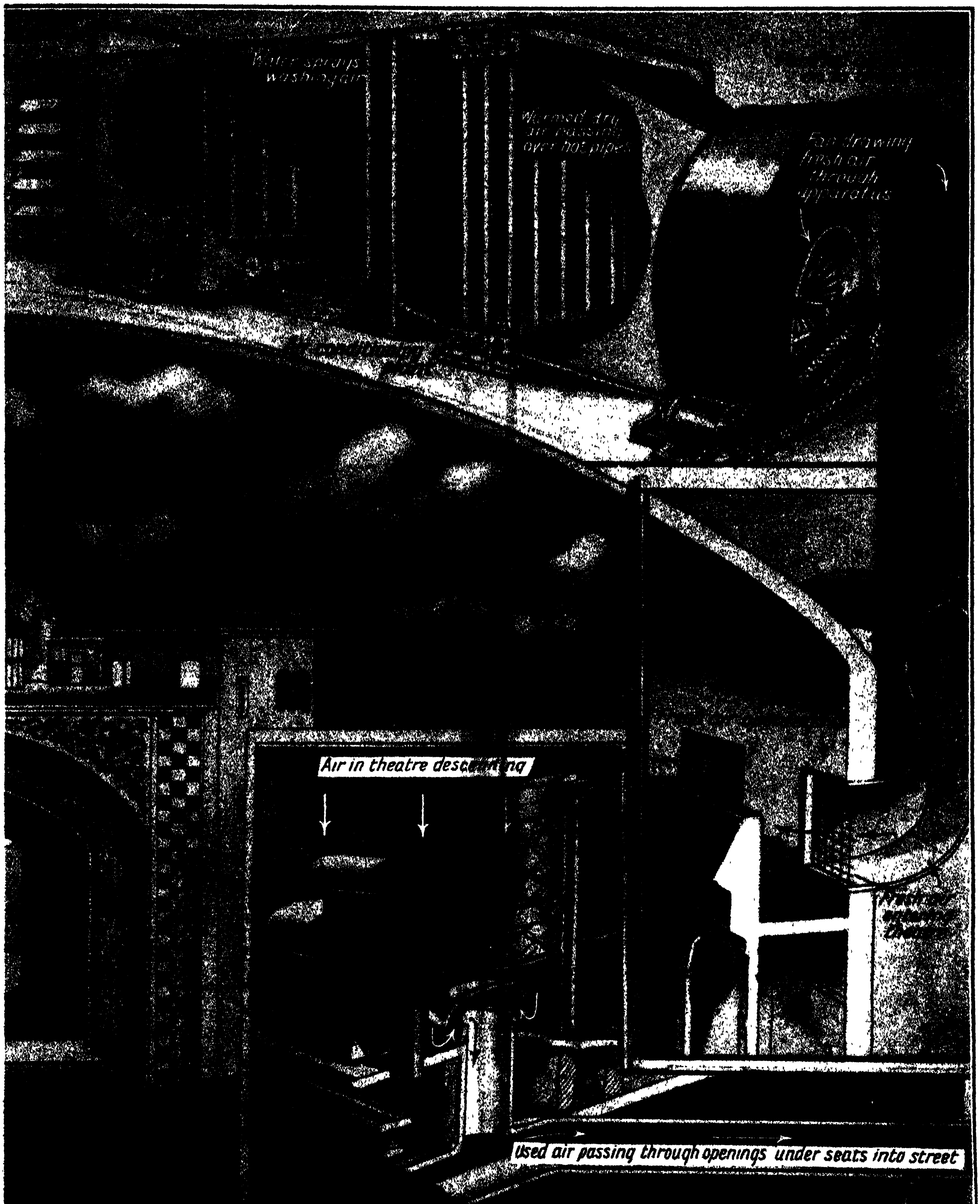
diagrams show how the most important parts of a car work and what they are for. On page 1212 of this book there is a similar drawing of a racing car which, of course, has a great many more parts, and on page 1263 you will find a more detailed account of a carburetter

THE INSIDE OF A MODERN CINEMA WITH



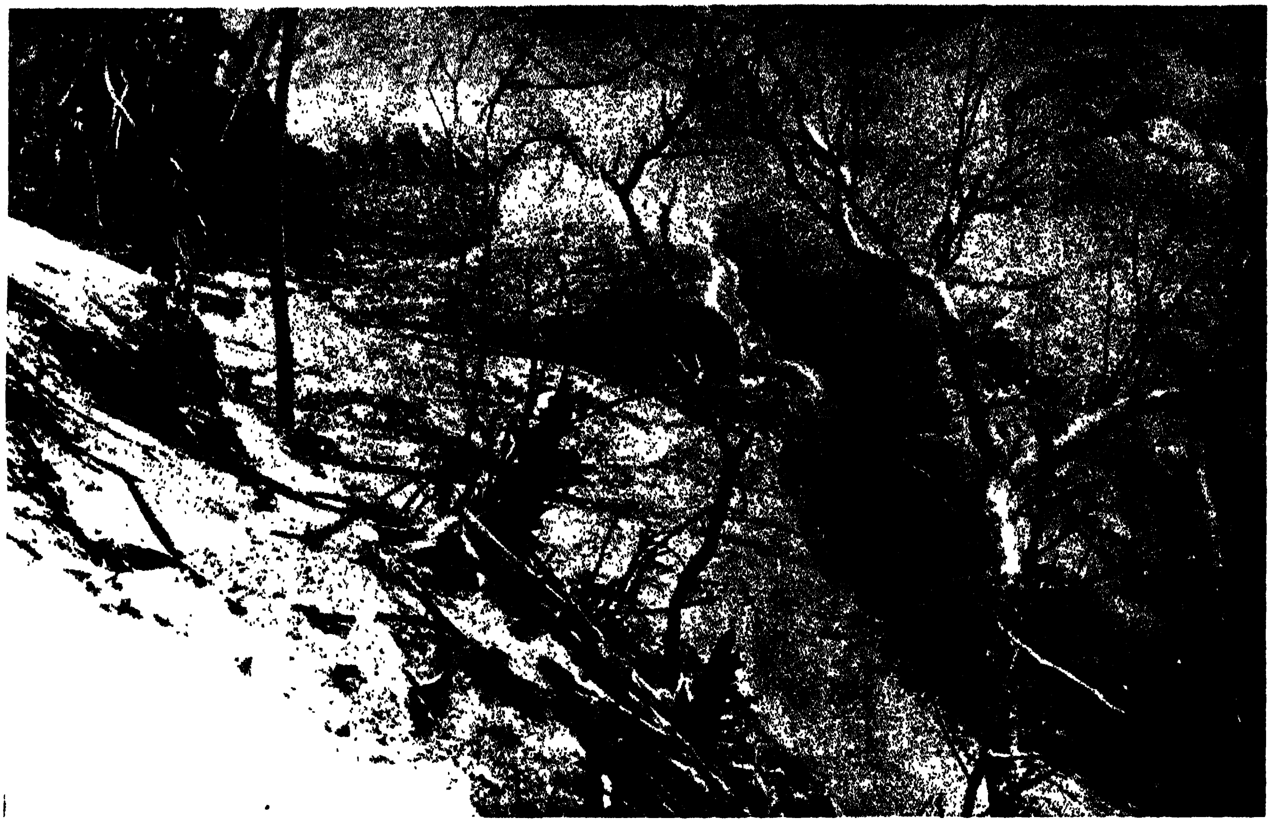
The modern cinema is certainly one of the wonders of the world. The luxury and comfort of the seats, the purity of the atmosphere, the beauty of the open-air illusion, the cleanliness of the building, and the perfection of the picture and sound projection would amaze the theatre-goer of even ten or fifteen years ago. Here we see one of the latest of the modern cinemas and its various parts. In the centre of the picture are the stage, the screen, and the wonderful starlit sky with clouds passing across it. The stars are points of light provided by electric lamps, as shown at the top of the page, and the moving cloud is produced by a projector seen in the top left-hand corner, worked automatically from the switch-board. A circular slide with cloud forms painted upon it moves round slowly between the light and the lens. Perhaps the greatest wonder of the cinema is the way the air is completely changed every few minutes, so that the atmosphere throughout the performance is even purer than it is out in the

ITS AIR-PURIFIER AND OTHER DEVICES

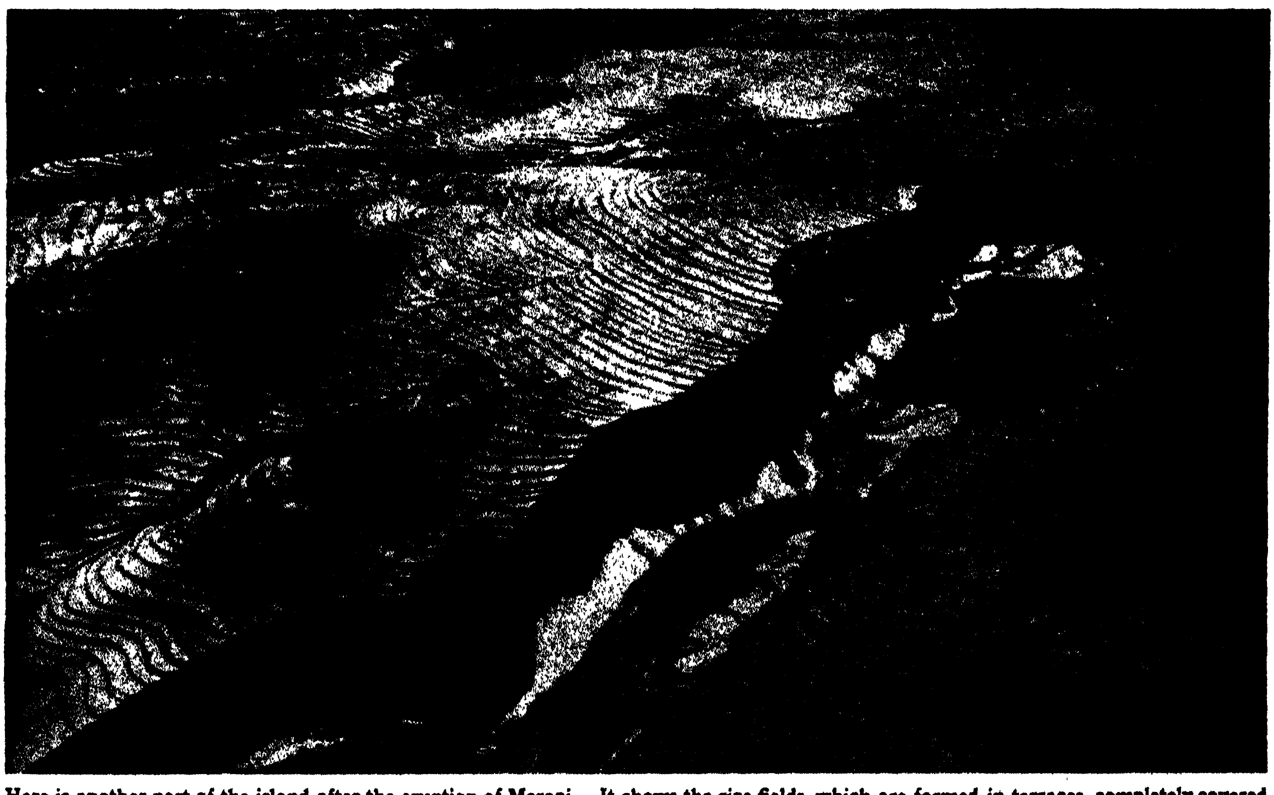


street. The method of ventilating the building is shown in the top right-hand corner of the drawing. Air is drawn into the conditioning plant by a powerful fan. It passes through a chamber in which sprays of water are playing, and is there cleansed of all dust and soiled matter. Then it passes over pipes which in winter warm the air, and finally travels down ducts and through openings into the cinema. It then passes through openings under the seats and through a channel into the street, fresh air constantly taking its place. In summer the air is cooled as it is sprayed upon by cold water. The cleaning of the building is performed by a powerful vacuum cleaning-plant with many connections throughout the cinema. Three loud-speakers stand behind the screen for reproducing sound with the film, and when a "turn" is being given, these, which are on wheels, are drawn away and the screen is raised revealing the scenery at the back of the stage. The lighting is worked from the switchboard beside the stage

THE SINISTER WORK OF THE VOLCANO



In this photograph taken in the Dutch East Indies we see the terrible devastation which is caused by a volcanic eruption. It shows how, after the eruption of Mount Merapi in Java in 1930, the stream of fiery lava poured over the country, burning the vegetation and leaving nothing in its trail but a scene of desolation. This part of the world is one of the Earth's worst volcanic areas



Here is another part of the island after the eruption of Merapi. It shows the rice fields, which are formed in terraces, completely covered by the volcanic ash thrown out by the mountain. The crops were destroyed, but the ash forms a fertile soil for future cultivation

WHY THE EARTH IS ORANGE-SHAPED

We all know that the Earth is not a perfect sphere, but is shaped something like an orange, but we may not know the reason for this. It is explained on this page. The flattening must have occurred in long distant ages, when the substance of which the Earth is formed was in a plastic state

THE Earth is a ball, but it is not an exact sphere. It is what the scientists call an oblate spheroid. It is a pity such difficult-looking words are used for simple things, for "oblate spheroid" simply means a spherical body that is flattened somewhat at the poles. In the case of the Earth this flattening is not very great when one considers the size of the globe. The diameter through the poles is about one 300th part shorter than the diameter through the equator, and of course such a small difference is not visible to the eye.

We can prove this for ourselves by trying to draw a circular figure on paper, say 10 inches in diameter, to represent the Earth. The only difference between the equatorial diameter and the polar diameter will be one 30th of an inch.

Some planets, such as Saturn, for instance, are far more flattened than our Earth. The flattening of that planet is thirty times as great, or in other words its polar diameter is one-tenth less than the diameter through the equator. The Earth's polar diameter is 7,899 miles, and its equatorial diameter 7,926 miles, a difference of 27 miles.

Centrifugal Force

Now why is the Earth flattened at all? Well, this is due to its rotation on its axis, and the flattening took place millions of years ago, when it was not, as now, a body with a solid crust, but was in a plastic state. The bulging at the equator and the flattening at the poles are due to centrifugal force.

We have already seen, on page 61, that as the Earth whirls round on its axis, the tendency is for everything on its surface to be hurled off by centrifugal force. This force is of course greater at the equator than it is at the poles, because the Earth is moving round much faster there than at the poles.

Now when the Earth was plastic the tendency was for it to be broken up by centrifugal force, just as a fast moving flywheel sometimes breaks for the same reason. When a flywheel is hurled to pieces by centrifugal force there is either some flaw in its structure or the wheel is going at too great a speed. The centrifugal force overcomes the cohesion of the particles. Generally speaking, in flywheels the cohesion is greater than the centrifugal force, and so the wheel holds together.

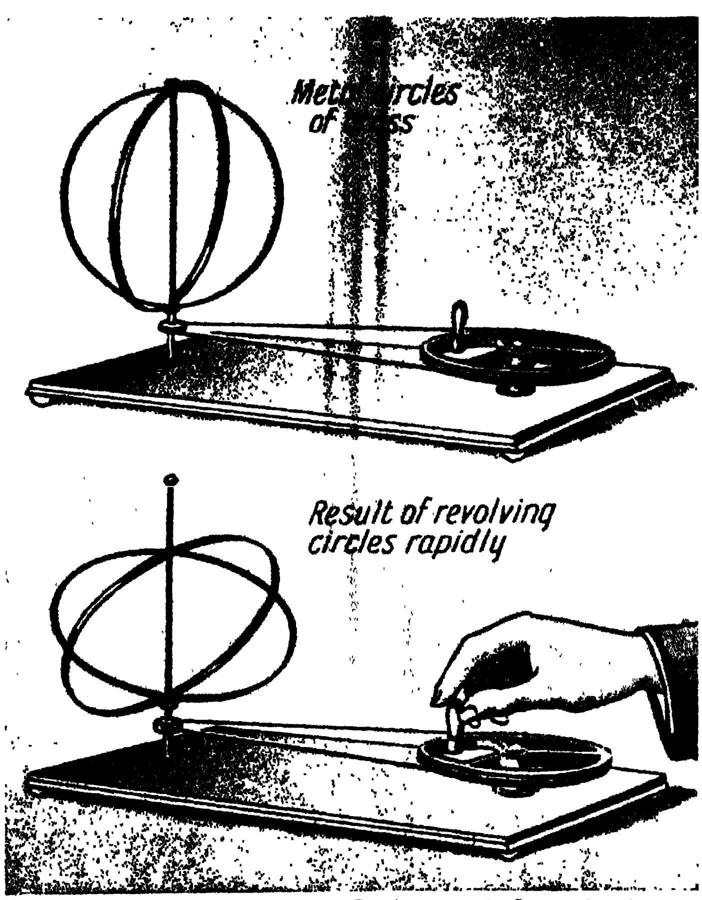
The same thing is true of the Earth. The cohesion of the particles has overcome the centrifugal force and prevented the Earth from breaking up. Some scientists, however, think that at some past period what is now the Moon was hurled off from that part of the Earth which is now the Pacific Ocean.

But although the Earth did not break up, the whirling round when it was in a plastic state caused the equator to bulge and the poles to flatten. To show how this occurred an experiment is often carried out with a simple apparatus shown in the picture on this page.

A brass axis carrying two different circular strips of metal placed at right angles to one another and fastened to the brass axis at the bottom, but not at the top, is whirled round rapidly by means of a mechanical device. At once the circles become flattened and the faster they whirl round the flatter they become. In the same way, if a skein of thread is suspended by a string and is then caused to rotate rapidly it assumes the shape of a flattened sphere.

Well, the Earth was once in a plastic state, and as it whirled round, it, like the brass rings and the skein of wool, became flattened and then when it cooled it retained this shape.

A freely rotating body is in stable equilibrium only when it is rotating about its shortest possible axis, and so any rotating body tends to take up the position or shape indicated.



A simple device which shows how the Earth came to be flattened at the poles

Weight Reduced

The greater centrifugal force at the equator lightens the weight of everything there. If an object weighed 289 pounds at the poles its weight at the equator would be reduced by one pound by centrifugal force. Of course being a little farther from the centre of the Earth the weight would be reduced still more, for objects at the poles weigh more because they are nearer the Earth's centre.

No measurements that we can make show that the Sun is flattened like the Earth and other planets. No doubt it is deformed in the same way, but the flattening must be very slight because of its slow rotation. The Earth turns on its axis once in 24 hours, but the Sun takes 25 days to make a complete turn, that is at its equator. The queer thing about the Sun is that the whole of it does not rotate at the same rate. Some parts take 27½ days to make a complete turn.

WHY EVEREST DOES NOT LOOK 5 MILES HIGH

Mount Everest does not look as if it were the highest mountain in the world, and the photograph on this page shows why. Height is, of course, reckoned from sea level, but the giant peaks of the Himalayas rise from a very elevated area, and so their real height is dwarfed by their surroundings.

In the photograph, where Mount Everest is the third peak from the right, it certainly looks less elevated than some of its sisters, and geographers have suggested that possibly when accurate measurements can be made of all these peaks there may be one or more that will prove to be higher than Everest.

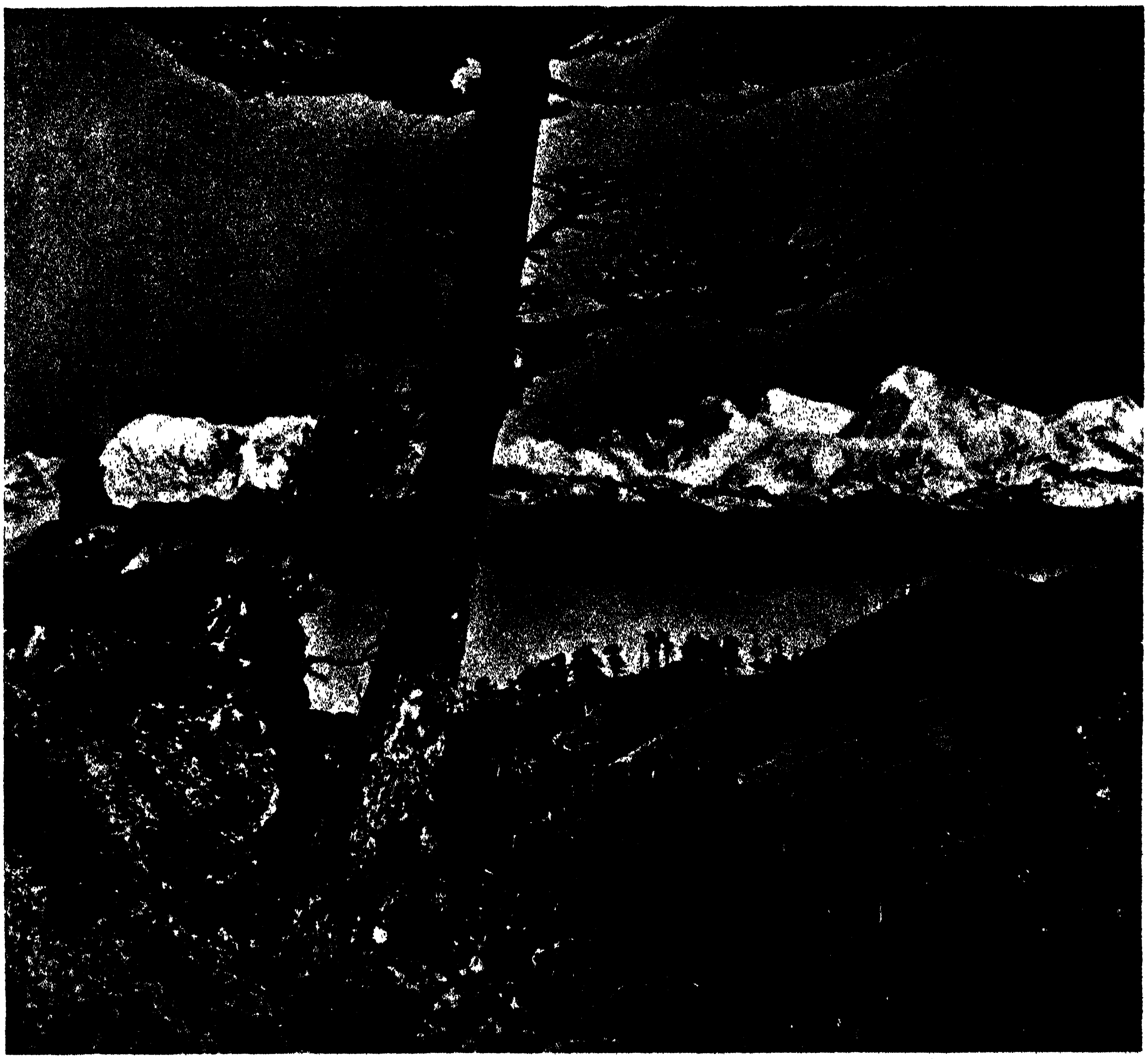
It is an interesting fact that the heights of the mountains on the Moon can be measured with far greater accuracy than these Himalayan peaks. The lunar mountains are measured almost exactly by means of their shadows cast on the surrounding plains.

Many of the towering peaks of the Andes which rise more directly from sea level and are more isolated appear to the eye far taller than the Himalayan Mountains. The conquest of Everest will, however, long hold first place among the achievements most coveted by mountaineers.

It seems strange that away up on these bleak and ice-clad peaks there should be a variety of animal life, yet such is the case. Those who have taken part in recent Everest expeditions tell us that they found the tracks of a wolf at a height of 20,000 feet, or nearly four miles. Bees, moths and spiders were found at 22,000 feet, grasshoppers at 18,000 feet, and butterflies at 17,000 feet.

Hares and wild goats, sheep and pigs were found at 17,000 feet, or more than three miles. The greatest height at which life was seen was 27,000 feet, where choughs were observed flying. This is 7,000 feet higher than the vulture reaches in the Himalayas, although in the Andes the condor has been seen 23,000 feet up.

Life must be very hard for these mammals, birds and insects in such inhospitable regions, although they are in many ways adapted to their surroundings. The butterflies have furry bodies to keep them warm.

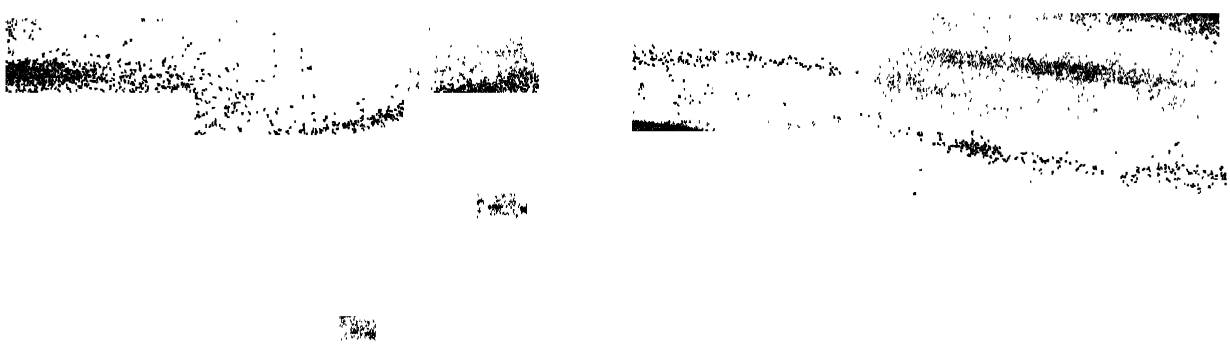


A remarkable photograph showing how Mount Everest, the third peak from the right, is dwarfed by its sister peaks of the Himalayas, and does not look anything like its great height because it rises from a base that is itself 12,000 feet above the level of the sea. Many peaks of the Andes look far higher to the eye. The summit of Mount Everest is 29,140 feet above the sea

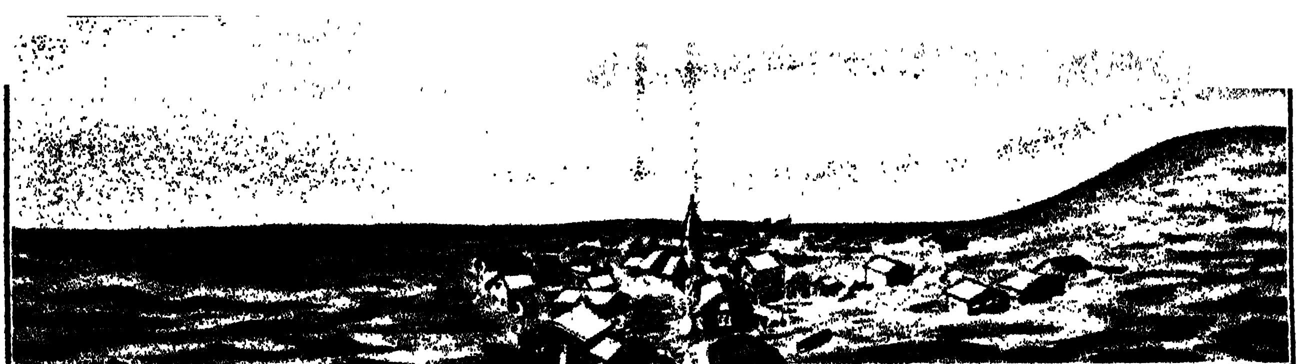
THE STRANGE TALE OF A BURIED TOWN

Towns have often been buried by drifting sand. We find this in the Sahara and Gobi Deserts. But in northern Europe something even more astonishing has happened. On the south-eastern shore of the Baltic Sea there used to be a town called Kunzen, shown here

On the great barrier beach close by were sand dunes, and as the wind blew it gradually carried the sand nearer and nearer to the town, till it began to bury the houses and the church, as shown in this picture, which is the second chapter in the strange history of Kunzen

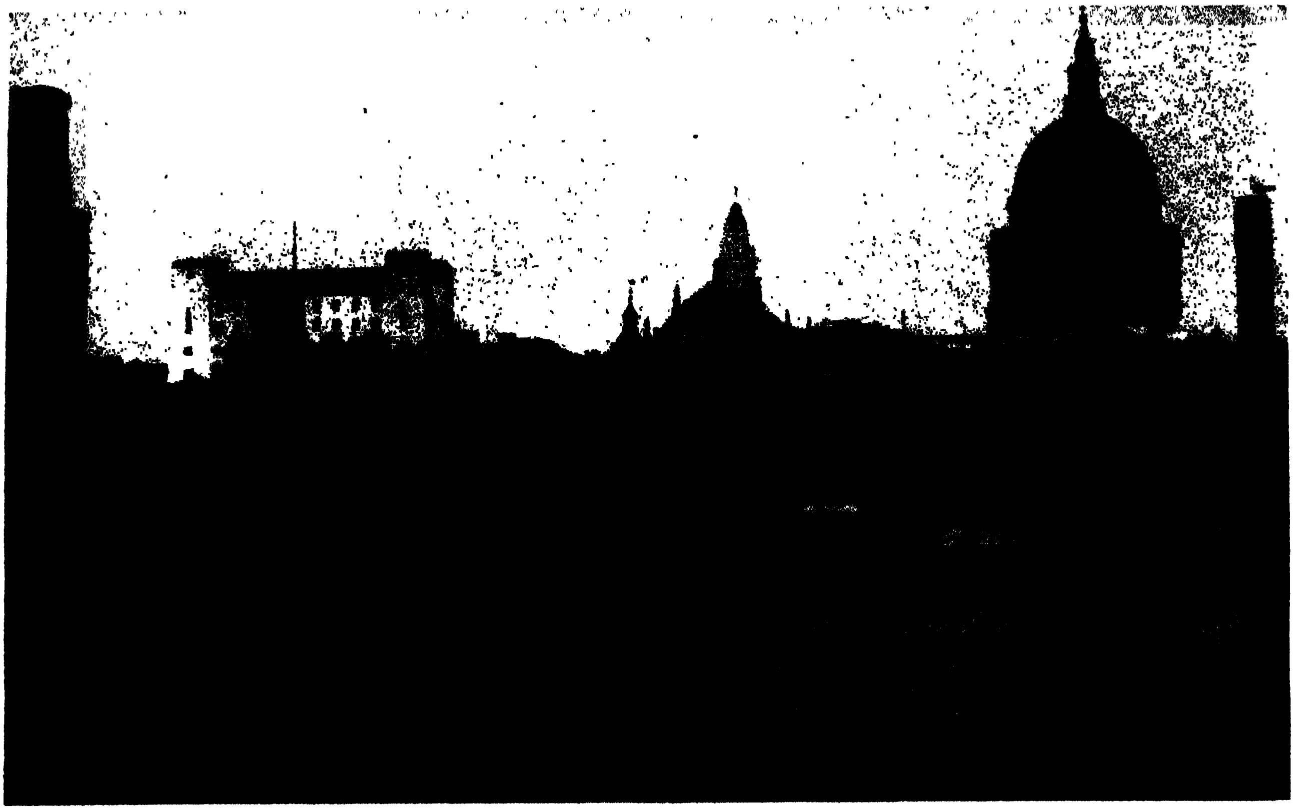


Nothing could stay the onward progress of the advancing sand dunes, and in the course of time the whole town was completely buried under the sand, as shown here. So far as any outward sign of the existence of Kunzen was concerned, it might never have been

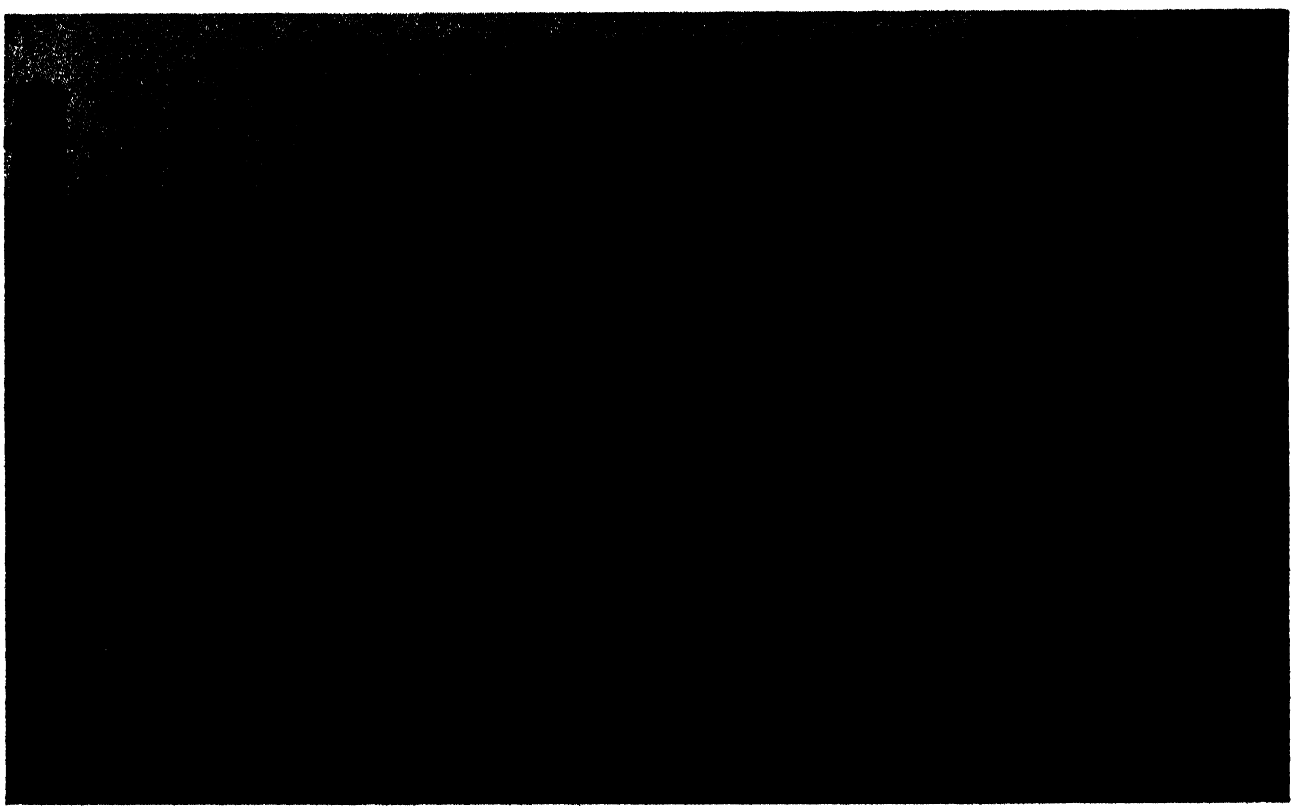


But still the sand dunes moved on, and in the course of years had passed so far that what had once been the flourishing town of Kunzen was once more exposed to sight. In this part of the Baltic shores other villages have similarly been buried and later on unveiled again

TWO PHOTOGRAPHS TAKEN IN THE FOG



This photograph, looking across the Thames towards St. Paul's Cathedral, was taken in a dense fog, yet all the details of the buildings come out quite clearly. The reason is that it was taken not by means of ordinary light but by the action of the invisible infra-red rays which, when light is broken up by a prism, lie beyond the red end of the spectrum or band of colour



Here we see a picture of the same scene taken at the same time by ordinary photography. Scarcely a detail is visible. In this case the photographic plates were of the usual kind sensitive only to ordinary light and not to the infra-red rays as in the upper picture

TAKING PHOTOGRAPHS IN THE DARK

Who would have thought even a year or two ago that photographs could be taken in the dark and in the fog? Yet this wonder can now be performed, and in these pages we see specimens of such photographs and read how it is that they can be taken. This is the latest development in photography

When photography was first invented, photographs were spoken of as "Sun pictures." This was because the pictures were really made by the light of the Sun acting upon a sensitive film on a glass plate, and books of popular science for boys and girls published in those days used to explain that the Sun and not any human painter was the artist.

If a good photograph was to be obtained it was absolutely necessary that there should be a good light, and all those who are amateur photographers know quite well how important this matter of light is.

Take a photograph of a garden or seaside beach or of a group of people when the Sun is out, and then a few minutes later take the same scene when the sky is overcast, and there is a wonderful difference between the two photographs. In one case all the detail comes out sharply, provided, of course, that the camera has been focused properly, but in the other case the result is a dull picture with little contrast of light and shade.

Quite recently there has been a wonderful development in photography, the most remarkable for many years. It is not now necessary to have a good light for the taking of a good photograph. In fact, a photograph of an outdoor scene can be taken in a thick fog; and even in a dark room, where nothing at all can be seen with the human eye, excellent photographs can be taken. Examples of these remarkable photographs are given on this and the opposite page.

How can such wonders be performed? Well, the explanation is that men of science have now discovered how to make photographic plates and films that are sensitive not only to ordinary light rays, but to what are known as the infra-red rays.

When the sunlight is broken up by a prism, as shown on page 450, we get a band of colours which we can see, consisting of violet, indigo, blue, green, yellow, orange and red. But the ray of light from the Sun contains more than these colours.

Beyond the violet at one end there are powerful rays which are invisible to our eyes, and they are known as the ultra-violet rays, which simply means "beyond violet." These have great healing properties, and are used by doctors for curing disease. They will also, as we have seen on page 710, put a valuable vitamin into such food as the dough from which bread is made.

At the other end of the spectrum or band of colour are still other powerful rays which cannot be seen by the eye. These are called infra-red, or "below red" rays, and it is by means of these infra-red rays that the photographs are taken in the fog and in the dark.

This photograph was taken by the camera in total darkness. No light was used, but the two irons, one on each side, had been heated by electricity, and although they were not luminous they gave out infra-red rays, and these fell upon the marble head of Venus and were reflected back upon the photographic plate, which was coated with a substance sensitive to the invisible infra-red rays

THE MARVELS OF MATTER IN MOTION

WHAT appear to be impossible feats are often carried out by means of science. Take, for example, the operation shown in the picture on this page. A man is actually cutting through a thick block of wood with nothing more formidable than a thin disc of tissue paper. Yet the paper cuts as surely and swiftly as a steel saw in the ordinary way.

How has this astonishing result been brought about? Well, the explanation is that the disc of paper, properly mounted, is whirled at a tremendous speed, and this has the effect of stiffening the paper till it becomes as rigid as a disc of steel.

An Astonishing Fact

Here is one of the astonishing facts of science. Motion adds hardness and stiffness to even a soft or flexible material. For example, a chain or rope, if it has its ends joined and is then whirled round at a very great speed, will become quite stiff as though it were a solid ring of steel, and if then suddenly released it will run for quite a long distance along the ground in the same way as a stiff hoop would do if it were set rotating.

As, however, the motion is reduced the chain or rope once more becomes flexible, and eventually when the motion has ceased altogether it will collapse in a heap on the ground.

Similarly the thong of a whip is limp and flexible when lying still, but given swift motion by lashing it will be so hard and rigid as to cut right into the flesh.

An equally astonishing feat as that of the chain or rope is that of firing a candle through a door. When the soft wax candle is given a tremendous speed by means of the explosive in the gun, the motion makes the soft substance so hard that it will go clean through a material like timber that would, in the ordinary way, flatten out the candle.

Cutting a block of wood with a whirling disc of tissue paper

It is this hardening of material by means of motion that gives the projectiles shot from modern guns by high explosives such astonishing penetrating power. No matter how thick or tough the steel plates may be that protect a warship, sooner or later a projectile can be shot at such a tremendous speed that it will penetrate the steel plates.

In fact, there is a contest always going on between the maker of the steel plate and the maker of the gun and projectile. No sooner is a tougher form of steel invented which will stop the passage of the latest projectile, than men set to work and invent a new explosive or a new method of speeding up the projectile which thereupon pierces the steel plate. Then the contest goes on all over again.

Movement is Energy

The science of motion as illustrated by such wonders as have been described is very fascinating, and some men of science tell us that matter consists of nothing more than motion or energy. It is also interesting to remember that in the first chapter of the Bible, where a picturesque description is given of how matter came into existence, it is said that the very beginning of things was when "the spirit of God moved." This statement, written so long ago, before the birth of modern science, is remarkably in keeping with the latest of scientific discoveries.

HOW LIGHT DECREASES AS IT GETS MORE DISTANT

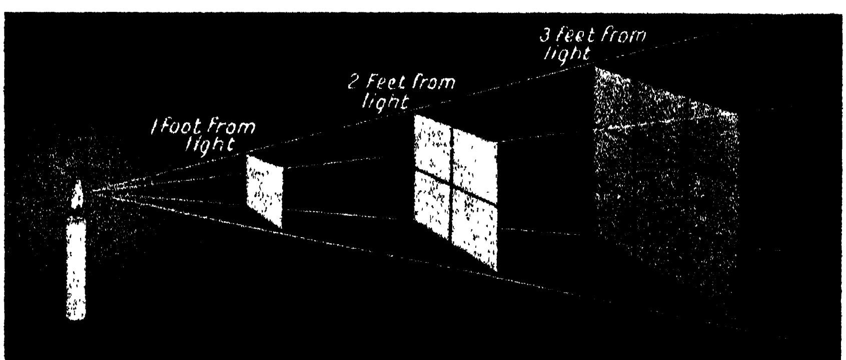
HOW does distance affect light? Well, of course, the farther we get from a light the less bright it seems. That is why the most distant stars, although glowing suns, are invisible to the naked eye, or appear merely as dim points of light.

But there is a curious thing about the effect of distance upon light. If we hang a one pound weight on a string the pull is one pound. If we double the weight the pull is two pounds. If we make the weight ten pounds the pull is ten pounds.

Now we might think that when we are two feet from a light its intensity is halved, and that when we are three feet away it is only one-third. But this is not the case. If we are two feet from a light the intensity is only one-quarter of what it is when we are one foot away. If we are three feet away the intensity is not one-third, but one-ninth.

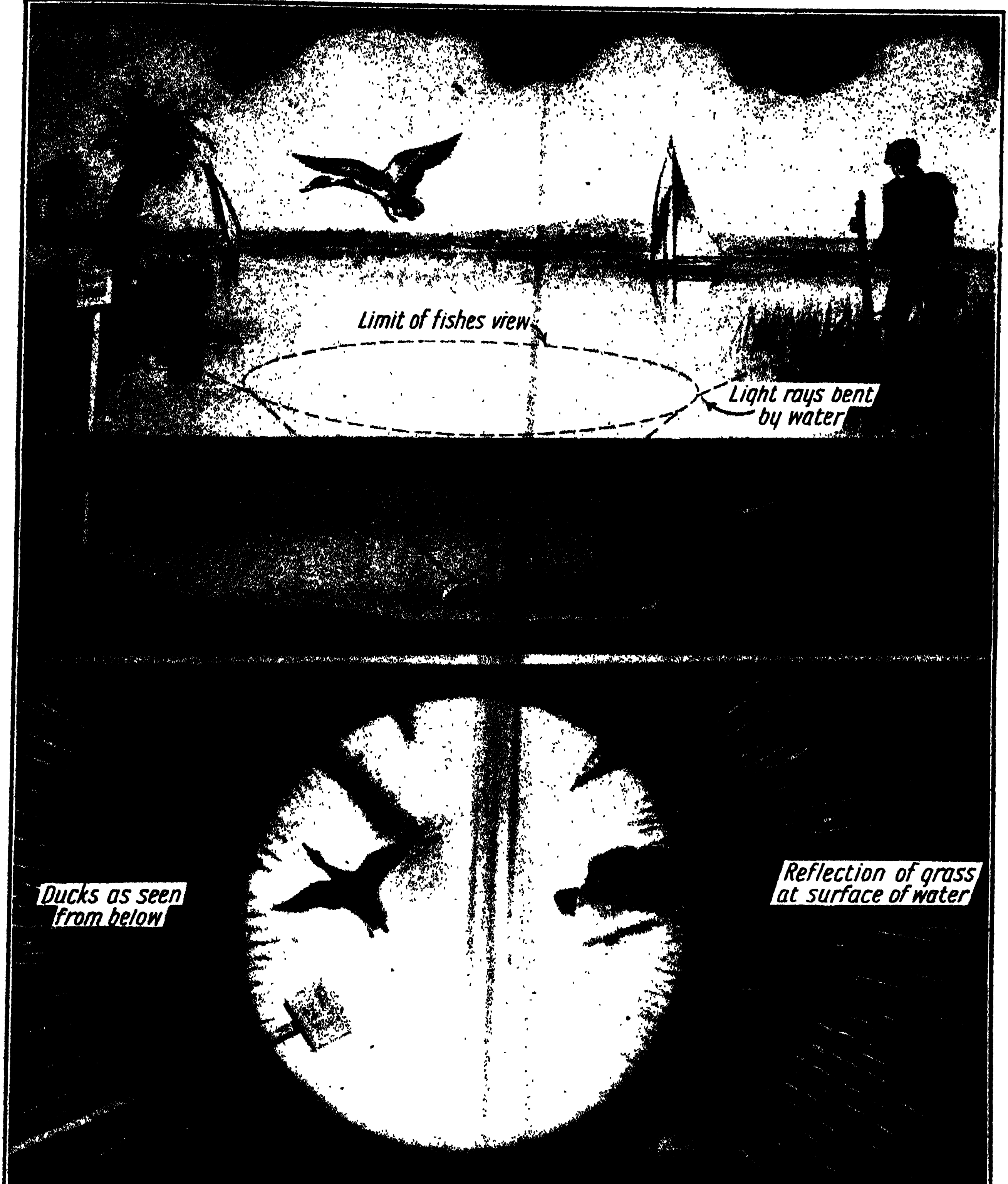
Scientists put this into learned language by saying that "the intensity of light decreases in proportion to the square of the distance from its source."

We can see from the picture-diagram why this is. A square card placed one foot from a candle flame receives a certain quantity of light. The rays of light if not intercepted would go on to a distance of two feet and three feet, as shown, but at two feet the same amount of light would illuminate a card four times the size of that at a distance of one foot, and at three feet it would illuminate a card nine times the size. Obviously, therefore, the same amount of light is spread out much more, and as we see the amount of spreading is in proportion not to the distance, but to the square of the distance.



This picture shows why light decreases in brilliancy not in the same proportion as our distance from it, but in proportion to the square of the distance; that is, at two feet a light is not half as bright as at one foot, but a fourth as bright

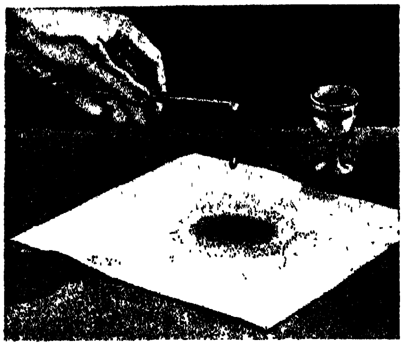
WHAT THE FISH SEES WHEN IT LOOKS UP



We often speak of a bird's-eye view, meaning a view from above such as a bird in flight would have, but here is a fish's-eye view, or in other words the kind of view that a fish must have as it looks up from the water in which it is swimming or resting. The circle in the upper picture shows its limit of view and the light disc below is the area enclosed in this circle as seen by the fish. Of course all objects immediately overhead, no matter what their colour, appear as silhouettes against the sky. Outside the circle of light the dark bed of the river or lake is reflected on the surface of the water, except where there are streaks of light caused by the reflection of grass on which the light is shining. The rays of light are, of course, bent by passing into the water from the air and the tops of objects above the water surface are seen where the rays of light from them fall within the dotted circle shown in the top picture. Thus the tops of the sails of the boats, the tree, the notice board, and the man would be seen

EXPERIMENTS IN CAPILLARY ATTRACTION

When a sponge is put into water or when blotting-paper soaks up ink, or when the oil of a lamp rises in the wick, the movement of the liquid is due to a force known as capillary attraction. The word "capillary" comes from a Latin word meaning "a hair," and this name has been used because capillary attraction is very marked in small hair-like tubes.



Liquid spreading on blotting-paper by capillary attraction

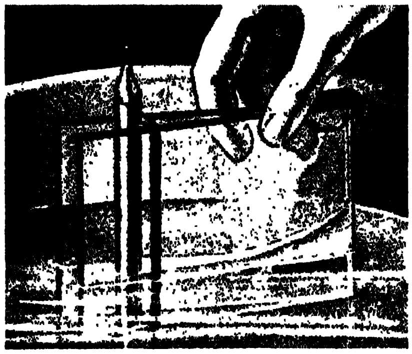
If we place a tube with a small bore in water, the water will rise in the tube by capillary attraction, and the smaller the bore the higher the water will rise. The pores of a sponge or a piece of blotting-paper are like so many capillary tubes, and that is why the water rises in these articles if they are dipped in the fluid.

There are a number of simple experiments which we can carry out at home to illustrate capillary attraction. One of the simplest is to let fall on a piece of white blotting-paper two or three drops of ink. Gradually the liquid will spread all round by capillary attraction, till quite a large patch is covered. If we use a solution of blue-stone or copper sulphate instead of ink we shall get a curious effect, for while the liquid spreads in all directions, the outermost part will be colourless. The solution is filtered as it spreads.

Watering a growing plant from a bowl by capillary attraction

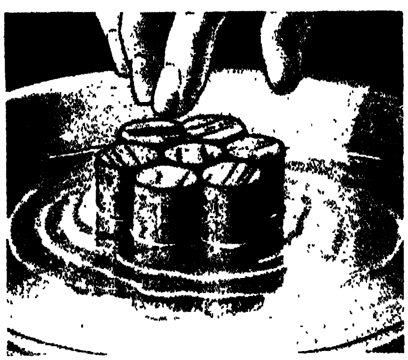
It is rather interesting to water a plant by capillary attraction, and the method of doing this is shown in the second picture. All we need is a basin of water standing close by the flower-pot, with a piece of rag or lamp-wick hanging from the basin over the flower-pot. By capillary attraction the water will rise in the cloth or wick, and drop into the flower-pot.

If we take two pieces of glass such as old photographic plates, put a thin blacklead pencil at one end and an elastic band to hold the plates together, and then while holding close the other ends of the plates, dip the whole into a basin of water, we shall find that by capillary attraction the water rises inside the plates at the closed end. The experiment is made more interesting if the water is coloured beforehand.



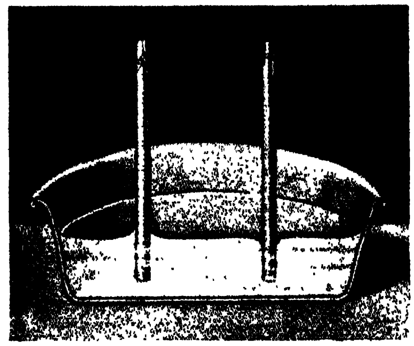
Water rising between two glass plates by capillary attraction

Another interesting experiment connected with capillarity is shown in the fourth picture. In a basin of water, if we place seven ordinary corks, of course they fall over and float on their sides. But we can make them float upright. How is this done? Well, before placing the corks in the water we stand one upright on the table and put the other six round it. Then taking the group with one hand and holding them tightly together, we plunge them under the water so that each cork is completely wetted. Still holding them, we bring them to the surface and release our grip. The corks now float upright in a group. By capillary attraction the water has penetrated between the corks, and by the power of cohesion holds them together.



Corks kept floating together in an upright position by capillarity

Let us now take two glass rods of equal diameter, wiping one clean and dry and greasing the other. Now suspend or hold the two rods in a basin of water so that the lower ends are in the liquid. A curious thing will be seen. The water touching the dry rod will be concave, as shown on the left, but where it touches the greased rod it will be convex all round, as shown on the right. The difference is due to capillary attraction and repulsion.



Capillarity illustrated by two rods in water, one dry and one greased

Next take two clean and dry glass tubes, one with a very small bore and one of larger bore. Hold or suspend them in a basin of water. The water rises in both tubes by capillary attraction, but higher in the small bore tube. Now let us dip similar tubes into a vessel of mercury or quicksilver. An opposite result is seen. The liquid is depressed and is convex upward all round.

A vessel of muddy water may not only be emptied by hanging one end of a piece of lamp-wick or a hank of cotton in it and allowing the other end to hang over the side of the vessel, but the water will be filtered in the process, for only the liquid will travel up the wick or cotton; the mud will be left behind. A wine-glass of water may be emptied by hanging a prawn or big shrimp over the rim, so that the tail end is in the water and the head over the side.

Capillarity illustrated by tubes in water and in mercury

Capillarity is due to the attraction of the molecules of a liquid for one another.

ROMANCE of BRITISH HISTORY

THE GREAT FIRE OF LONDON

There have been bigger fires than the Great Fire of London in Charles the Second's reign, but there has never been one which so stirred the imagination or has held such a place in history. Men in their fear and ignorance thought that it must be a judgment from heaven, and for a time they were so stunned by the calamity that they scarcely had the heart to start rebuilding. But gradually, during the next few years, a finer and healthier city rose on the ruins. Here is the story of the Great Fire of London

At three o'clock on the morning of Sunday, September 2nd, 1666, Mr. Samuel Pepys, the capable and industrious Admiralty clerk who lived in Seething Lane, near the Tower of London, was awakened excitedly by his maidservant Jane. She had not yet gone to bed, having had to sit up preparing a feast which Mr. Pepys was giving to some friends later in the day.

The maid's reason for waking her master at such a strange hour was that she had seen the reflection of a great fire in the City, and felt that she must let him know. Fires in the wooden London of that period were very frequent affairs, but nevertheless Mr. Pepys rose, as he tells us, slipped on a nightgown, and went to the window. It seemed nothing unusual, and appeared as far off as Mark Lane, so there was nothing to worry about, thought Mr. Pepys, and went back to bed.

No Ordinary Fire

At seven o'clock he got up for the day and thought he would look out of the window to see how the fire was getting on. In the daylight it seemed to have died down and appeared farther off than it did in the darkness. Jane, however, who seems to have been a persistent news gatherer, came in to tell Mr. Pepys that she had heard that 300 houses had been burned down during the night, and that the fire was still raging and making its way to London Bridge.

This was evidently no ordinary fire, so Mr. Pepys, always a man of an inquisitive turn of mind, determined to make investigations, though he little realised that the fire of which he had seen the beginnings four or five hours before was to be the biggest fire the world had known since Nero burned the capital of the Roman Empire. The result of his investigations, Mr. Pepys tells us in his Diary.

"I made myself ready presently," he says, "and walked to the Tower, and there got up upon one of the high places, Sir J. Robinson's little son going up with me; and there I did see the houses at that end of the bridge all on fire, and an infinite great fire on this and the other side the end of the bridge; which, among other people, did trouble me for poor little Michell and our Sarah on the bridge.

"So down with my heart full of trouble to the Lieutenant of the Tower, who tells me that it begun this morning in the King's baker's house in Pudding Lane, and that it hath burned down St. Magnus Church and most part of Fish-street already. So I down to the water-side, and there got a boat, and through bridge, and there saw a lamentable fire. Poor Michell's house, as far as the Old Swan, already burned that way, and the fire running further, that in a very little time it got as far as the Steele-yard, while I was there.

"Everybody endeavouring to remove their goods, and flinging into the river, or bringing them into lighters that lay off; poor people staying in their houses as long as till the very fire touched them, and then running into boats, or clambering from one pair of stairs by the water-side to another. And among other things, the poor pigeons, I perceive, were loth to leave their houses, but hovered about the windows and balconys, till they burned their wings and fell down."

Mr. Pepys, summoned by his maid, slipped on a gown and went to the window to see the fire, but there seemed nothing to worry about

The weather was fine and warm, and had been for a long time, so that eveything was very dry, and owing to a drought there was a shortage of water. A strong wind was blowing at the time, and the flames simply raced along, licking up house after house at such a rate as quite stupefied the people. Nobody seemed to be making any serious attempts to stay the fire. What all were concerned about was removing their goods as the fire approached their premises.

Rousing the Lord Mayor

When the flames had begun to get a mastery, the Lord Mayor, Sir Thomas Bludworth, who lived in Gracechurch Street, was roused by excited citizens and persuaded to leave his bed and visit the scene. He was not very pleased at being disturbed and peevishly said: "Pish! A woman might put it out!"

He had seen scores of fires before in the narrow streets of London, and they always burned themselves out in an hour or two. Why worry about this one? But the poor gentleman had quite misjudged the situation. So far from a woman putting it out, all the King's horses and all the King's men could not do so till it had wiped out five-sixths of the capital and had spread far beyond the walls and gates of the City proper.

In those intolerant days any disaster was put to the credit of political opponents or those of another religion, and Roman Catholics, Frenchmen and Dutchmen were all accused of having started the fire. Later on, indeed, a poor demented Frenchman who had accused himself of the crime, telling an obviously

impossible and ridiculous story, was tried and hanged, though nobody seriously believed him guilty. Another Frenchman walking quietly along the street during the fire was felled with an iron bar wielded by a blacksmith.

There seems no mystery, however, as to how the fire really started. It began in a baker's shop at Pudding Lane, ten doors from Thames Street. Some faggots were lying by the side of the baker's oven and these seem to have become overheated and burst into flame.

At any rate, soon after one o'clock the baker, one Faryner, woke up with a choking sensation caused by smoke which filled the house. He roused his family, and he, his wife, daughter and serving men escaped through a garret window and by way of a gutter into a neighbouring house. His maid-servant, however, remained behind and lost her life, being the first victim of the Great Fire of London. Perhaps she was too nervous to make her way along the gutter to safety.

It would seem that if energetic steps had been taken without delay the fire need not have spread beyond the baker's house, for one eye-witness tells us that he watched Faryner's place burning for an hour before any other building was attacked, and the next-door neighbour was able to get all his goods away before his house caught fire. When, however, a wind sprang up, sparks and burning fragments were driven about and soon the fire was anything but an ordinary fire. It now grew too powerful, and spread too quickly to be put out with buckets or squirts, the only extinguishing apparatus of the day.

The Lord Mayor, as soon as he was summoned, was urged to have a number of houses pulled down so that there might be a gap across which the flames could not leap. Large grappling irons were kept in the churches for this very purpose. But poor Bludworth was a very nervous man, quite unsuited for his high position. He was unable to come to any decision, and feared that if he had the houses pulled down the owners might sue him for damages and there would be tedious legal actions. "Who shall pay the charge of rebuilding the houses?" he asked. He would, therefore, give no authority, and so the flames galloped onwards.

Fine Food for the Flames

By eight o'clock they had reached London Bridge and burned down many of the houses that lined both sides. The area where it started was a very unfortunate one for a fire. The streets were painfully narrow, the upper storeys of the wooden houses almost touched those on the other side of the street, and the shops and cellars and warehouses were filled with the most combustible kinds of materials, such as pitch, tallow, oil, hemp, and other things used by ships. On the wharves lay hay, timber and coal. Soon the Church of St. Magnus the Martyr at the foot of London Bridge was destroyed by the fire, but it was only one of over eighty churches, including St. Paul's Cathedral, that were to be lapped up one after the other by the flames in the next day or two.

The fire now began to spread in two directions, along the riverside towards the Temple, and northward towards the Royal Exchange. Mr. Samuel Pepys, after learning all he could about the fire, went off to Whitehall and had an interview with King Charles and his brother, the Duke of York. He explained what he had seen and urged that unless the King commanded houses to be pulled down nothing could possibly stop the fire.

After a consultation, Charles ordered Mr Pepys to go to the Lord Mayor and command him from the King to spare no houses that he thought it was necessary to pull down to stay the fire in any direction. If any soldiers were wanted to help in the work, or to keep order, he could have all he desired.

Pepys rode as far as St. Paul's and then, as he tells us, walked along Watling Street "as well as I could..every creature coming away loaded with goods to save, and here and there sick people carried away in beds. Extraordinary good goods carried in carts and on backs. At last met my Lord Mayor in Canning-street, like a man spent, with a handkercher about his neck. To the King's message, he cried, like a fainting woman, 'Lord! what can I do? I am spent: people will not obey me. I have been pulling down houses; but the fire overtakes us faster than we can do it.' That he needed no more

The Great Fire of London with St. Paul's burning in the background. From an old engraving

soldiers; and that, for himself, he must go and refresh himself, having been up all night. So he left me, and I him, and walked home; seeing people all almost distracted, and no manner of means used to quench the fire.

"The houses too so very thick thereabouts, and full of matter for burning, as pitch and tar, in Thames-street; and warehouses of oyle, and wines, and brandy, and other things. Here I saw Mr Isaac Houblon, the handsome man, prettily dressed and dirty at his door at Dowgate, receiving some of his brother's things, whose houses were on fire, and, as he says, have been twice removed already; and he doubts (as it soon proved) that they must be in a little time removed from his house also, which was a sad consideration. And to see the churches all filling with goods by people, who themselves should have been quietly there at this time."

The mass of the citizens seem to have been quite helpless. They knew not what to do, and felt that the only safe place was the river. No one thought of trying to save his house, but only of getting his goods to a place where they could not be reached by the flames.

Porters at a Premium

It was the golden age for porters, boatmen and lightermen. They charged fabulous sums to carry goods for the distracted citizens, and when they had obtained all the available money they then made bargains to receive a portion of the goods they saved. The river was full of lighters and boats taking in goods; furniture and other property was floating in the water, and as Pepys tells us, "I observed that hardly one lighter or boat in three that had the goods of a house in but there was a pair of virginals in it." A pair of virginals was the name given to a musical instrument, ancestor of the piano, that came before the spinet and harpsichord.

At first prospective victims of the fire had removed their goods to the houses of friends a few streets off, but as street after street became involved everybody wanted to get his goods outside the City.

Pepys was advised to carry away his money and plate to Bethnal Green. "Which I did," he says, "riding myself in my nightgown in the cart; and Lord! to see how the streets and the highways are crowded with people running and riding and getting of carts at any rate to fetch away things."

This was at four o'clock on the Monday morning. When Pepys reached the house of his friend at Bethnal Green he found the poor man very tired with being up all night receiving goods from many of his friends and acquaintances. The house indeed was full of goods. The difficulty was to make any progress through the streets, for they were simply blocked with people and goods and vehicles. The King's brother, with his guards, did his best to keep order in the streets.

The most ridiculous stories began to spread about foreigners and others being seen with fire-balls which they threw into houses through the windows, causing the fire to break out in fresh places, but there is no evidence whatever of this. The flames, fanned by the powerful wind, needed no assistance from fire-balls or foreigners.

King Charles went into the City and was very energetic in directing operations for the stay of the fire

Nevertheless the fire-ball story was believed. Word went forth that a poor Frenchman walking along was carrying "balls of fire," and he was brutally attacked. A widow woman in the same area hurrying along with some fully-hatched chickens in her apron which she had saved from the fire, was attacked and badly wounded because the chickens were mistaken by the crowd for fire-balls.

King Charles and his brother, the Duke of York, rode about the City, and indeed they seem to have been the most energetic in directing operations for the stay of the fire. The train-bands were called out and men were summoned from the fleet to help in demolishing the houses and making gaps across which the flames could not leap.

Not only were the houses pulled down with fire-hooks, but they were blown up with gunpowder. Of course, all this work took time and still the fire spread. As it went towards the Tower of London, the greatest alarm was felt, for here the Navy kept a magazine of gunpowder, and if that blew up London Bridge and half the City would be blown up with it. The goldsmiths, particularly, were very scared, for they had taken their stocks of gold and plate for safe-keeping to the Tower.

The noise caused by the crackling of the flames, the falling of the buildings, and the blowing up of houses, together with the bursting of stones as church after church was involved in the flames, caused the greatest fear, and the flare by night and the gloom of the smoke by day made people feel that this was a calamity sent by Providence to punish them for their sins. Preachers did not hesitate to foster such an idea.

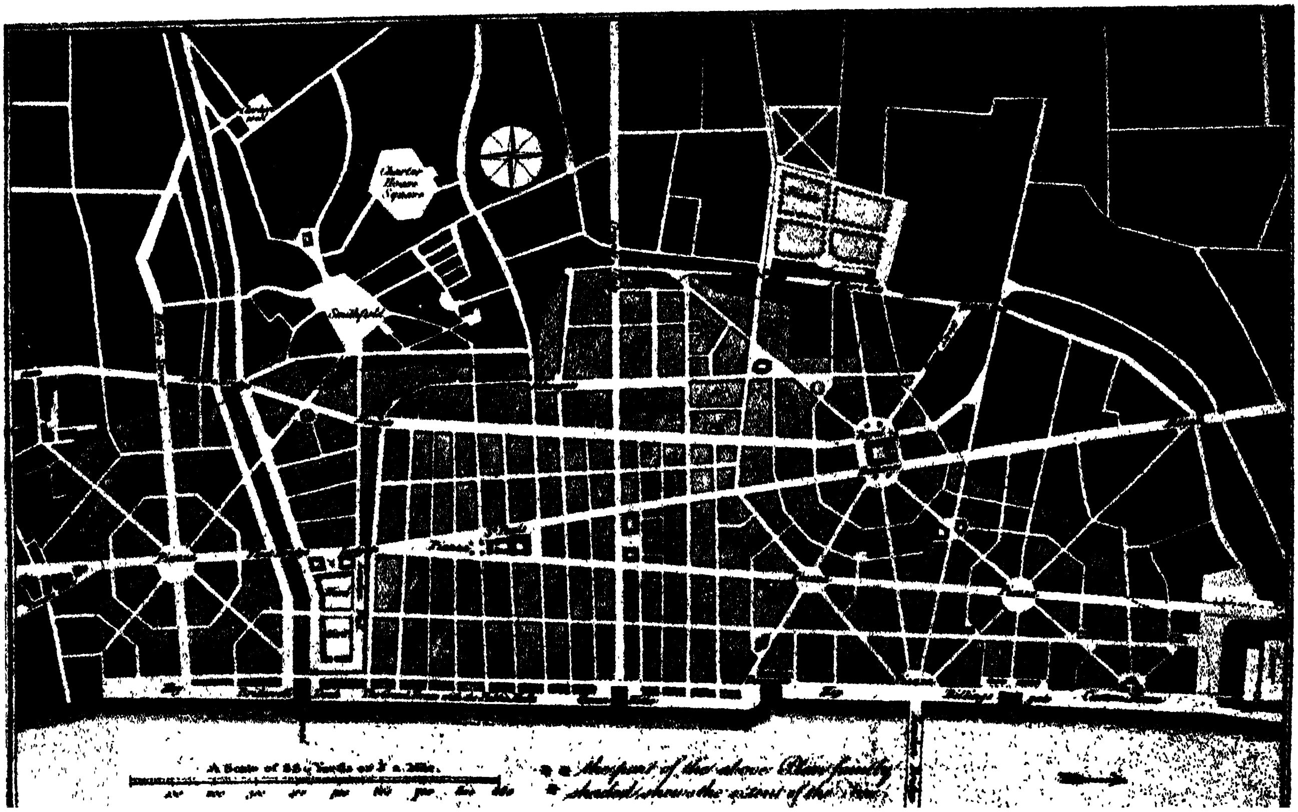
Wasting Precious Water

What little water there might have been was lost by people digging up the conduits so as to get at the water more easily and thereby allowing it to run to waste. The pall of smoke was seen fifty miles away and told the tale of something unusual happening before human messengers could explain the facts.

The speed with which the fire travelled appalled men. Those who went to bed at a great distance from where the fire was raging were up at dawn to find their roofs alight and their rooms filled with smoke.

Of course, thieves were busy. Many unfortunate people, accepting the help of those who offered to assist them in saving their goods, never saw the helpers or the goods any more.

On the Monday night the fire was still spreading in different directions, and John Evelyn wrote in his diary: "Oh, miserable and calamitous spectacle! Such as haply the world had not seen since the foundation of it, nor be outdone till the universal conflagration thereof. God grant mine eyes may never behold the like, who now saw about 10,000 houses all in one



Sir Christopher Wren's plan for building a fine new and spacious London. The lightly shaded part is the area that was totally destroyed by the Great Fire If Wren's plan had been carried out London would have been a magnificent city

flame! The noise and cracking and thunder of the impetuous flames, the shrieking of women and children, the hurry of people, the fall of towers, houses and churches, was like a hideous storm; and the air all about was hot and inflamed, that at the last one was not able to approach it, so that they were forced to stand still, and let the flames burn on, which they did, for near two miles in length and one in breadth."

As the fire progressed westward the King became alarmed for the safety of the Palace at Whitehall and Westminster Abbey Fortunately when it met the brick buildings in the Temple it was so well resisted that progress was much slower, and although a large part of the Temple was burned, the flames were finally brought to a stop in this area Although it had a narrow escape, the Temple Church was saved.

But the fire raged in other parts of the City, destroying street after street till nothing but ruins stood between the river on the south and Cripplegate on the north and the Temple on the west and the Tower of London and Leadenhall Street on the east.

For a time St. Paul's Cathedral, the tallest and largest building in the City, stood unharmed, looking down upon the universal devastation. There was an open space all round, and this seemed to spell safety so that the merchants and booksellers whose shops were in the neighbourhood carried their goods into the Cathedral and the Churchyard

Under the floor of the Cathedral in the vaults was a parish church known as St. Faith's. It was a strange position for a parish church, but it seemed the safest place in London, and so the booksellers piled their stocks of books there, thousands of volumes, including many in rich bindings.

But about eight o'clock on the Tuesday evening flames were seen to break out on the Cathedral roof. Flaming brands had been carried up by the wind and the dried timber of the roof soon began to burn furiously. After a time the roof fell in, red hot stone and burning timber falling upon the floor and setting the whole building in a blaze

A Terrible Loss of Books

Scaffolds had been erected inside and outside the building for repairs, and these added to the fuel. The lead of the roof melted and poured down, and when the great beams and stones crashed down they took the floor with them and soon St. Faith's Church, with its thousands of books, was a burning cauldron. It is said to have been the most serious loss of books since the destruction of the great library at Alexandria. Only the massive walls remained standing. The heat was so great that no one could approach within hundreds of yards.

A writer of the time, Dr. Taswell, who was rector of Newington, has left us an account of the scene. "Soon after sun-rising," he says, "I endeavoured to reach St. Paul's. The ground was so hot as almost to scorch my shoes, and the air so intensely warm that unless I had stopped some time upon Fleet Bridge to rest myself I must have fainted under the extreme languor of my spirits.

"After giving myself a little time to breathe I made the best of my way to St. Paul's And now let any person judge of the violent emotion I was in when I perceived the metals belonging to the bells melting; the ruinous condition of the walls; whole heaps of stone of a large circumference tumbling down with a great noise just upon my feet, ready to crush me to death

"I prepared myself for returning back again, having first loaded my pockets with several pieces of bell metal. In my way home I saw several engines which were bringing up to its assistance all on fire, and those concerned with them escaping with great eagerness from the flames which spread instantaneous almost like a wild-fire; and at last accoutred with my sword and helmet which I had picked up among many others in the ruins, I traversed this torrid zone back again."

The Cathedral burned for forty-eight hours after the first flames were seen on its roof Mr. Pepys wrote to his father to tell him of the dreadful disaster, but as the Post Office was burned down the letter could not go. Early on the morning of Wednesday he was awakened by his wife who told him that there were

"new cryes of fire, it being come to Barking Church which is at the bottom of our lane." He decided to take his wife and his gold, amounting to £2,350, to Woolwich and "Lord!" says he, "What a sad sight it was by moonelight to see the whole City almost on fire that you might see it plain at Woolwich as if you were by it."

The great walls of the City did not stay the fire's progress, and it raged for a time in the Liberties, that is the streets immediately outside the walls. Samual Pepys, curious as ever, mounted to the top of the tower of the Church of All Hallows, Barking, at the end of his street, to survey the scene. Fortunately, although the flames licked the walls of the Church and even destroyed the clock-face and burned down the rector's house adjoining, they did no more, and the Church continued to stand as it does to-day.

"I up to the top of Barking Steeple," says Pepys, "and there saw the saddest sight of desolation that I ever saw; everywhere great fires, oil cellars and brimstone and other things burning. I became afraid to stay there long and therefore down again as fast as I could the fire being spread as far as I could see; and to Sir W. Pen's and there ate a piece of cold meat having eaten nothing since Sunday but the remnants of Sunday's dinner.

A Sad Sight

"Here I met with Mr. Young and Whistler, and having removed all my things and received good hopes that the fire at our end is stopped they and I walked into the town and find Fanchurch-street and Gracious-street and Lumbard-street all in dust. The Exchange, a sad sight, nothing standing there, of all the statues but Sir Thomas Gresham's picture in the corner.

"Into Moore-fields (our feet ready to burn walking through the town among the hot coles) and find that full of people and poor wretches carrying their goods there, and everybody keeping his goods together by themselves; and a great blessing it is to them that it is fair weather for them to keep abroad night and day."

More than 100,000 homeless people (200,000 people, says Evelyn) were camping out in Moorfields, Finsbury Fields, and as far north as Islington and Highgate, some in tents, some in rough huts, and others with no shelter at all. Never had there been seen such a sight in England's history.

At last, on the fourth day, what with the dropping of the wind and the blowing up of whole areas with gunpowder to make wide barriers against the flames, the fire burned itself out. The seamen had worked like Trojans to save what was left of the City, and it was largely due to their efforts in demolishing houses that the fire was stopped.

When the roof of the Inner Temple Hall caught fire a seaman named Richard Rowe climbed up, and sitting astride the ridge beat the flames out. His exploit saved the ancient building, and the Benchers in gratitude rewarded him with a gift of £10.

The remarkable thing is that in this unprecedented fire the loss of life is said to have amounted to no more than six persons. The first was the maidservant who died in the house where the fire began, and some of the others owed their deaths entirely to carelessness or covetousness.

The Monument erected on the spot where the Great Fire of London began. It was originally intended by Wren, who was an astronomer, as a telescope tube but it swayed too much in the wind

As soon as it was seen that the fire was subdued, King Charles rode out to Moorfields attended by a few gentlemen, and addressed the citizens. It is to his credit that he told the people that the fire was due to no plot by Frenchmen, Dutchmen, or Catholics, but was a pure accident, and added that he would take particular care of them all.

He did so, for he at once sent orders into the country round for food to be carried into London. Vast quantities had been destroyed in the fire and there was danger of famine. Then he ordered that the people should be billeted in inns, churches, and other public buildings, and the people who had houses in the unburnt part of the City were very charitable and took in the homeless. Within a day or two it was remarked with wonder that the 100,000 or more people who had been camping out had all found shelter

At last stock could be taken, and it was found that the fire had levelled 373 acres within the City walls, and over 63 acres outside Four hundred streets with 13,200 houses had been burned and 87 parish churches Among the public buildings destroyed were St. Paul's Cathedral, the Royal Exchange, the Custom House, Newgate Gaol, the Sessions House, and the Guildhall The halls of 52 City Companies were burned, several prisons, and many millions of pounds' worth of goods.

But the Great Fire did some good. It removed for ever the possibility of another such disaster. When the City was rebuilt it was ordered that all the main streets should be of such a breadth "as may with God's blessing prevent the mischief that one side may suffer if the other be on fire."

That great man, Sir Christopher Wren, who was made the principal architect for the rebuilding, drew up plans for a new City which would have made London the most magnificent capital in the world. But greed and jealousy prevented the plans being carried out. However, we have his monument in St Paul's Cathedral

London Is Built Anew

The rebuilding of the City took many years, and was not done street by street. Buildings rose up here, there and everywhere as their owners could find money, and at last the various houses joined up and formed new streets

On the Monument which marks the spot where the fire began, is an inscription about the rebuilding which says, "Three short years completed that which was considered the work of an age." This is not true. First of all a kind of mushroom town of shacks and tents sprang up, and then very slowly houses were built, but these were so isolated that for some years afterwards rich merchants were afraid to occupy their new houses for fear of robbers, there being no neighbours who could come to their help.

The difficulty was to find money for rebuilding, as up to the Great Fire of London there had been no such thing as fire insurance. That was one of the great boons which came out of the fire.

However, as the years went by the streets were completed, and not only a finer, but far more healthy city arose.

A VAST UNIVERSE ACTUALLY IN THE MAKING

The universe of which our solar system forms a part must at one time have been a great whirling mass of glowing gas which later condensed and formed the stars, including our Sun, with his family of planets. In this truly amazing photograph, taken at Mount Wilson Observatory, U.S.A., with a 10¾-hour exposure, we see a universe in course of formation. This spiral nebula in the constellation Canes Venatici is sometimes called the Whirlpool Nebula. In it we see the whirling masses of gas condensing into bunches or knots, and these are believed to be the beginnings of what will later be groups of stars. The nebular matter seems, first of all, to form these big condensations, and then later to break up into individual stars

WONDERS OF THE SKY

QUEER FACTS ABOUT THE MOON'S HEAT

The variations of temperature on the Earth between day and night are not very great, although of course we complain if we get a fairly warm day and then experience a cool night. How should we like to live on a world like the Moon, where in the daytime the temperature rises probably well above boiling-point, and then at night falls to about 244 degrees below zero? Here we read something about the astounding temperature conditions which have been found to exist on the Moon

The Moon is the nearest heavenly body to our Earth. It is less than a quarter of a million miles away, and the wonderful 100-inch telescope at Mount Wilson Observatory in America brings it so close to our view that we can see objects on it no bigger than St Paul's Cathedral.

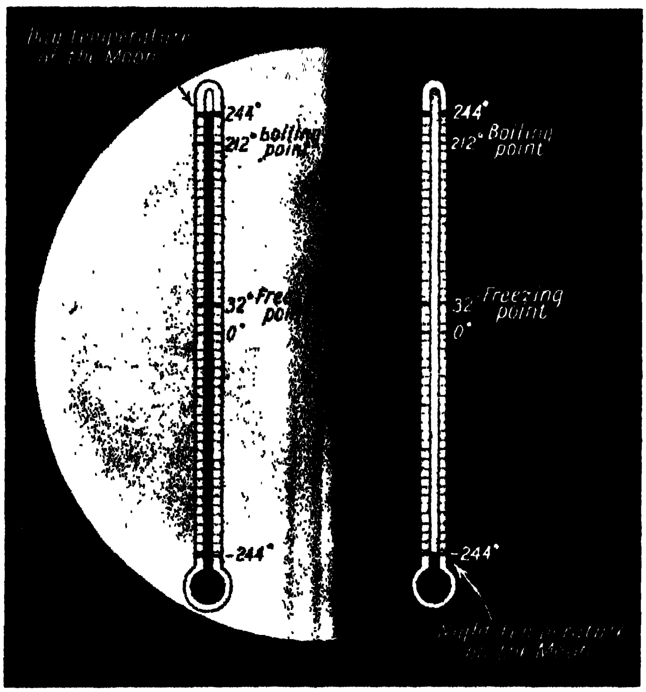
But conditions on the Moon are very different from what they are on the Earth. As we already know, there is probably no atmosphere and no water. The Moon is a dead world, but apart from the absence of air and water it would be very difficult indeed for us to live there even if we could travel to the Moon. The weather conditions are really astonishing. The temperature is both much hotter and much colder than anything we get on the Earth, and the suddenness of the changes is quite astounding.

On an average the Moon is about as far from the Sun as is our Earth, and so it receives about the same amount of light and heat per square mile as we receive. The Moon reflects to us only a part of the light which it receives from the Sun, and the light we get from the Moon when it is full and shining at its brightest is less than one half millionth of that which we receive from the Sun. Different observers get different results, and one astronomer declares that the light of the full Moon is only one 618,000th that of sunlight.

But we do not always have a full Moon shining down on us, and if we take into consideration the whole month, then the amount of light and heat which we receive from the Moon is less than one-millionth of that which we receive from the Sun. In other words, we receive from the Sun in half a minute more light and heat than comes to us from the Moon in a year.

But what are conditions on the Moon itself? Well, of course, the temperature on the Moon depends upon the amount of heat which it receives and the amount that is reflected back. It also depends upon the rate of this radiation. Any heat that the Moon reflects directly does not heat it at all, and this amount astronomers tell us is about 17 per cent. The remaining 83 per cent of heat which the Moon receives from the Sun raises its temperature.

We do not know exactly what the rate of radiation is, but we know that it must be very rapid, for when the Moon is eclipsed by the Earth, that is, when the Earth's shadow falls upon it and shuts off the Sun's rays, it very quickly ceases to radiate any heat at all.



This picture-diagram shows the Moon, the left-hand half of it with the Sun shining upon it in the lunar day, and the right-hand half in darkness during the lunar night. The difference in temperature, as can be seen from the thermometers which have been drawn on the two halves, is 488 degrees. This means that any living things would be frizzled in the day and frozen stiff at night

Now the Earth's atmosphere plays a very important part in helping the Earth to retain a large proportion of the heat it receives from the Sun, and it also helps to equalise the climate. But there being no atmosphere on the Moon, the Sun's heat is not held, nor are the temperatures of night and day at all equalised.

The latest observations made by astronomers show that during the long day the temperature rises probably as high as 244 degrees Fahrenheit, that is, the heat is more than boiling-point on the Earth. In other words, the ground becomes so heated that it would immediately roast any organic substance placed on its surface.

The long day lasts for 14 of our days, and then comes the long lunar night of 14 days. At once the rocks, having no blanket of atmosphere, give off the heat they have received, and the temperature falls to about 244 degrees below zero, a far greater cold than anything experienced on the Earth. The lowest temperature known in the Arctic regions is about 90 degrees below zero.

How much of the heat which the Moon receives from the Sun during the long day is radiated to the Earth? Well, the estimates of astronomers vary a good deal, but it is now believed that this amounts to about one 185,000th of the heat it receives.

For a very long time astronomers found it quite impossible to detect any heat on the Moon at all. When they concentrated the rays received from it by a large lens, the heat was too feeble to be shown at all by the most delicate thermometer. With modern apparatus, however, which is amazingly delicate, the heat radiated from the Moon can be distinctly perceived, although it is still very difficult to measure it with anything like accuracy.

With such extraordinary extremes, that is, a range between day and night of 488 degrees Fahrenheit, it is impossible to imagine any kind of living creatures existing on the Moon. The day temperature is too great and the night temperature too little to sustain life.

Apart from the question that an atmosphere is absolutely necessary to us for breathing we may be thankful that the Earth has this envelope making life not only tolerable, but pleasant.

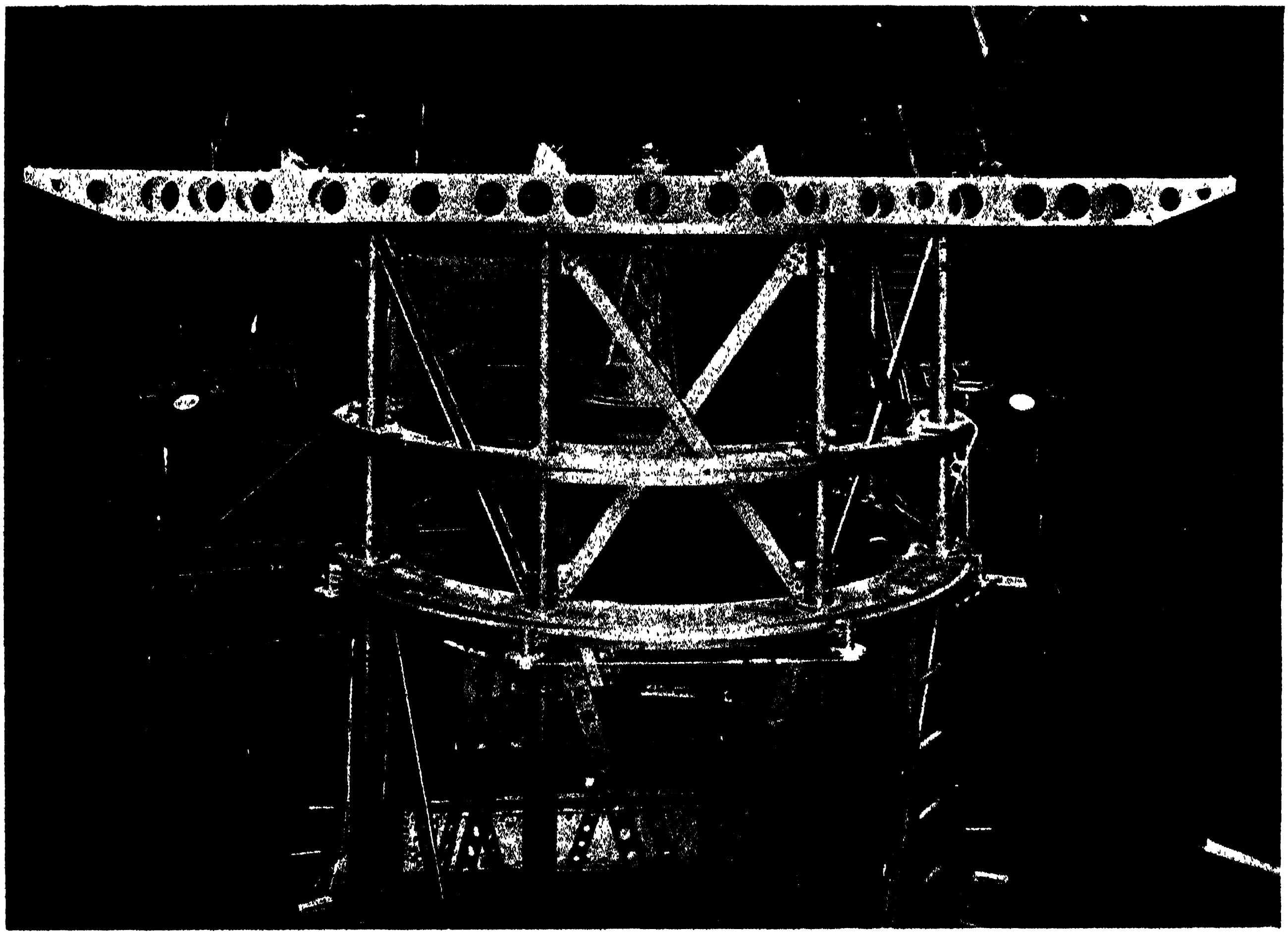
MEASURING THE WIDTH OF A GIANT STAR

UNTIL recent years it was quite impossible to measure the diameters of any of the stars. Stars are quite unlike planets, in that they appear to us as a mere point of light and show no appreciable diameter. In the cases of the planets, of course, even the more distant ones, there is a definite diameter, which can be measured Stars are too far away to show even the smallest diameter. Their light reaches us as though it were a wave from a single point

These rays of light are reflected parallel to the beam to a second pair of mirrors near the middle, and those mirrors throw the light down the tube to a large mirror from which they are reflected into an eyepiece. When the instrument is adjusted the two pencils or lines of light from the two halves of the star interfere with one another, thus forming a series of alternate bright and dark fringes that cross the image of the star. By a series of intricate calculations based on the amount of inter-

Slosson, " the same size as a plate one foot in diameter, seen from a distance of about 800 miles."

Several other stars have been measured by means of the interferometer, and some of them have much larger diameters than even Betelgeux. Antares, for example, the chief star in the constellation of the Scorpion, has a diameter more than half as great again as that of Betelgeux. If Betelgeux be represented by a circle $2\frac{1}{2}$ inches in diameter, then Antares is represented



The great interferometer at Mount Wilson Observatory in California, by means of which the diameters of some of the stars that appear only as points of light can be measured

But by means of a wonderful instrument invented by Professor A. A. Michelson, the famous American scientist, the diameters of some of the stars can now be measured. The instrument is known as an interferometer, and is shown in the photograph on this page, given by courtesy of Mount Wilson Observatory, where the instrument is in use.

It is far too complicated to explain in detail. Pencils or thin lines of light from each of the two halves of the disc of a star are received by small flat mirrors near the ends of the great beam, 20 feet long, which can be seen on top of the framework.

ference, and the distance between the mirrors on the great arm, the diameter of some of the stars can be measured.

The whole scientific world was amazed when in December, 1920, it was announced that by means of this wonderful instrument the great star Betelgeux, which is the bright orange-coloured star in the constellation Orion, had been measured and was found to have a diameter of 250,000,000 miles, or 300 times the diameter of our Sun. The diameter of Betelgeux is almost as great as that of the orbit of the planet Mars as it travels round the Sun, and yet, as observed from the Earth, it seems, according to Dr. Edwin E.

by a circle 4 inches in diameter. Its diameter is, in fact, 400 million miles, and its volume about 70 million times greater than that of our Sun.

But although so big, these stars are very much less dense than our Sun, that is, their matter is much more drawn out. Our Sun is only a quarter of the density of the Earth, but these huge stars have been described as " merely giant gasbags, minus the bag." They are, indeed, very much lighter than air, and in some cases a thousand times lighter; and their condition, wonderful as it may seem, must be something like that prevailing in what we call a vacuum.

THE WONDER OF A MODERN ROPE FACTORY

Rope-making to-day is a greater industry than ever it was, even in the days of sailing ships, and very elaborate machinery is used in the production of cordage of all kinds. Here are some details about rope-making and the raw material used in the process

WHAT should we do without rope and string? Our everyday purchases are tied up in neat parcels by means of string, and for thousands of purposes rope is essential. There is the clothes-line in the garden, the rope tied round our trunk when we go on a long journey, the cables that hold the ship to the shore, the ropes used on the sailing boat, and in the making of scaffolding, the rope that pulls the church or school bell, and so on.

It is difficult to think of a world without rope or string. In fact, directly man came to live as anything more than a mere animal life he found the need of rope and string of some kind, and he soon learnt to make it, crudely at first, but ever improving in strength and texture.

For centuries the making of string and rope was entirely a hand operation, but nowadays a great rope factory is full of the most complicated machinery.

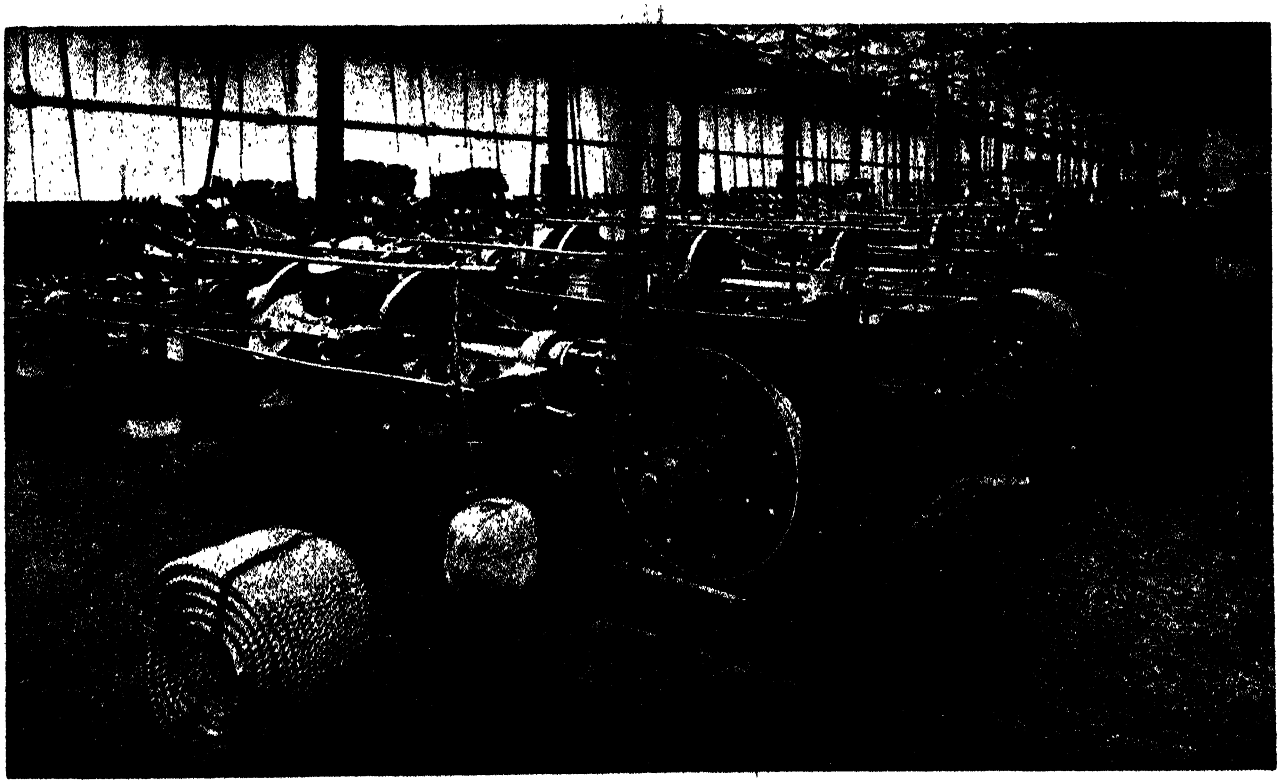
The sisal plant now much used in rope and twine making, as it appears when growing

There are machines to soften the fibre when it arrives in bales, to hackle and card it, or comb it from its tangle, to draw out the fibres and spin them into thread, to twist the thread into twine or rope, to polish the cord, and to wind it into bales.

No factory, indeed, has a more complicated mass of machinery than a rope factory. It is only in this way that the immense quantities of twine and rope required for modern use can be turned out fast enough.

A works like that of the Belfast Ropeworks Company in Northern Ireland, which covers over forty acres of ground and is the biggest rope factory in the world produces every week several hundred tons of rope and twine, running into hundreds of thousands of miles.

Manila hemp is still the chief fibre used in rope making, but sisal, which is grown in different parts of the British



From the spinning frame the bobbins of yarn are taken to the "Former" or rope-making machine seen on the left of this photograph, where a specified number of threads are twisted into a strand according to the circumference of the rope required. The strands as they are formed are wound on to large bobbins and then transferred to a Laying or House machine shown on the right, to be formed into a rope. There are, of course, many machines of each type in a large modern rope factory

Commonwealth, is also much used, especially for the small size cords.

Manila fibre is obtained from the abaca plant of the Philippine Islands, and is exported in large quantities from the capital, Manila, from which it derives its name.

The plant has to be about three years old before it is ready for cutting, and the fibre is obtained from the fleshy leaf-stalks by scraping away the surrounding soft parts with a dull knife. Both a coarse and a fine fibre are obtained in this way, the finer material coming from the parts near the edge of the stalk. The coarser fibre from the inner parts of the leaf is much stronger than true hemp, and makes the best of all cordage.

Manila like the Banana Plant

The manila plant is remarkably like a banana plant. From the underground stem rise huge leaves whose overlapping stalks make a trunk that rises to a height sometimes of twenty feet. This supports the immense leaf-blades and a heavy cluster of flowers, which produce fruit very much like the banana in outward form.

The whole work of preparing the fibre for export is carried out in very primitive fashion by the natives of the Philippines, but the grading of the different quality fibres is done under Government supervision

The sisal plant, a native of Yucatan, is now cultivated with great success in British East Africa and other places. Large areas of Tanganyika and Kenya produce excellent types of this very valuable fibre.

Here, again, the fibre is extracted from the leaf in a similar manner to manila, except that the operation, instead of being performed by hand,

Manila hemp growing in a plantation

is done by machinery, which gives a high production.

Cutting is commenced when the plant is four years old. Though the fibre is shorter in length than manila, it makes up into a rope equal to a good-class manila rope. Large quantities of binder twine for harvesting purposes are made from sisal fibre.

In addition to these materials, Russian, Italian, Indian and New Zealand hemps are also used in large quantities for rope-making.

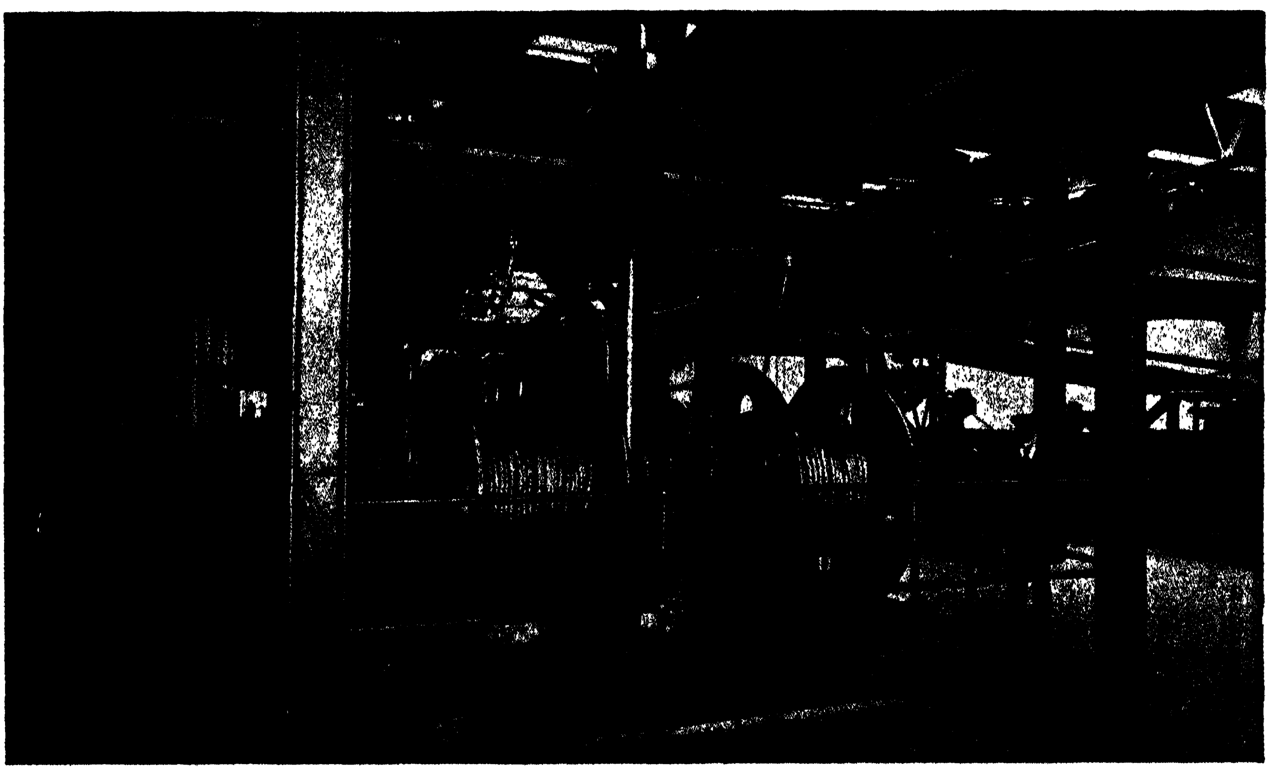
When the fibre arrives at the rope-works the bale is opened and spread by one machine, being afterwards combed out into a sliver or ribbon by other machines. These machines consist of two chains with a number of steel bars linked together, and carrying rows of pins, which comb the fibre and draw it out.

Different Kinds of Rope

Then it goes to the spinning frame, where it is spun or twisted into thread, the threads being afterwards twisted or " laid " into different sizes of cordage

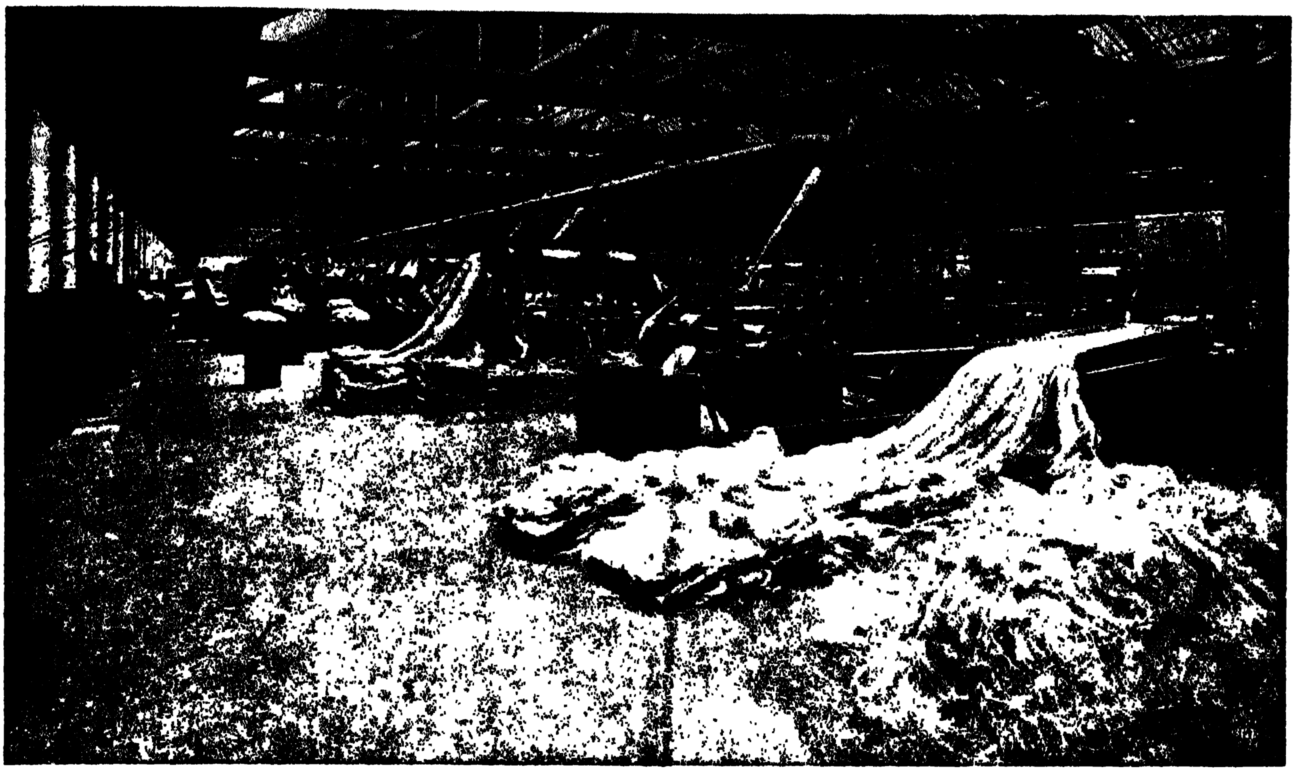
The latest type of machine for this purpose is known as a " house " machine, and the machines are built to suit the different sizes of rope required

There are many types of rope. Hawser laid ropes have three strands, and are used for shipping, capstans, baling and for towing barges. The shroud-laid rope, which is four-stranded and built round a centre core, is used for sailing ships, while cable-laid ropes constructed by laying three or more hawser-laid ropes together, are used for towing, oil-well drilling, trawl and herring warps, and sometimes for ships' fenders. By far the greater quantity is used for the fishing industry

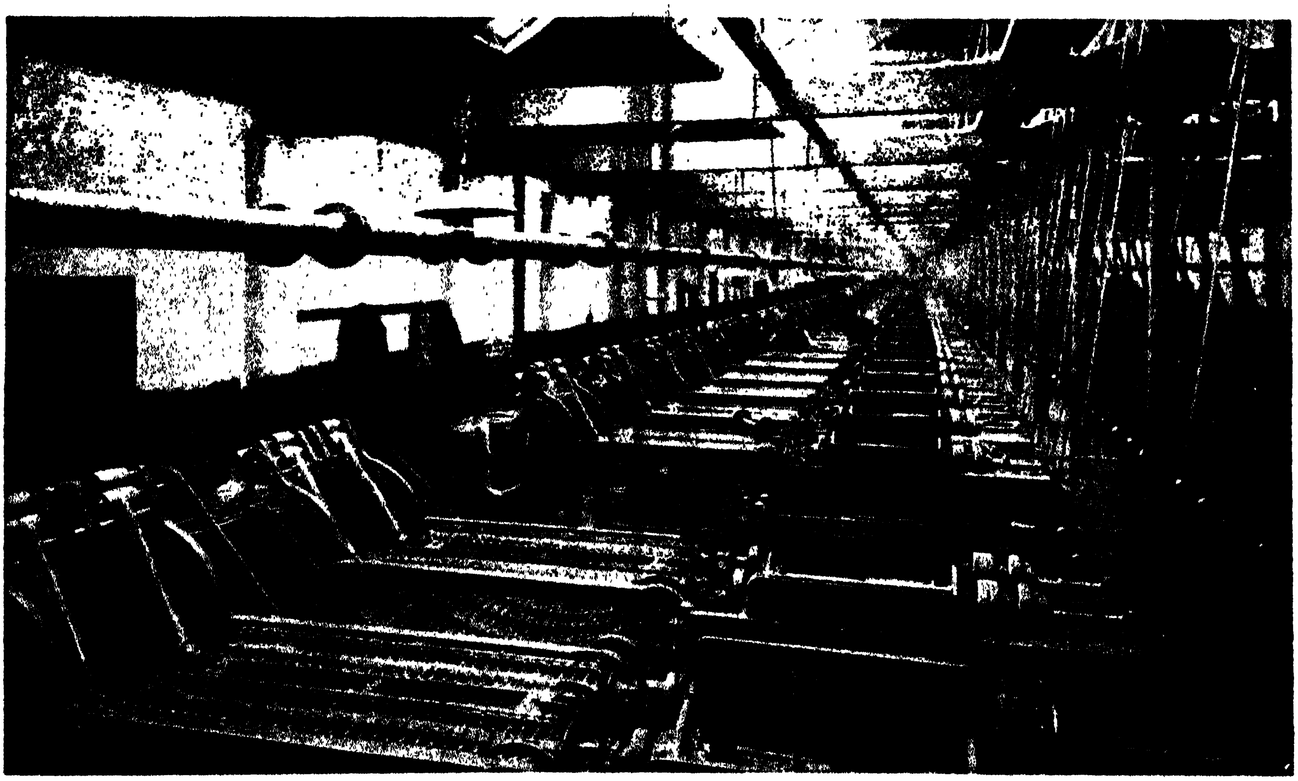


Here we see the end of the rope-laying machine with the rope being wound on to large drums. Ropes from one to six inches in circumference are usually made on the House machine, while tarred and larger ropes are made in the rope walk shown on page 792

COMBING AND SPINNING THE HEMP

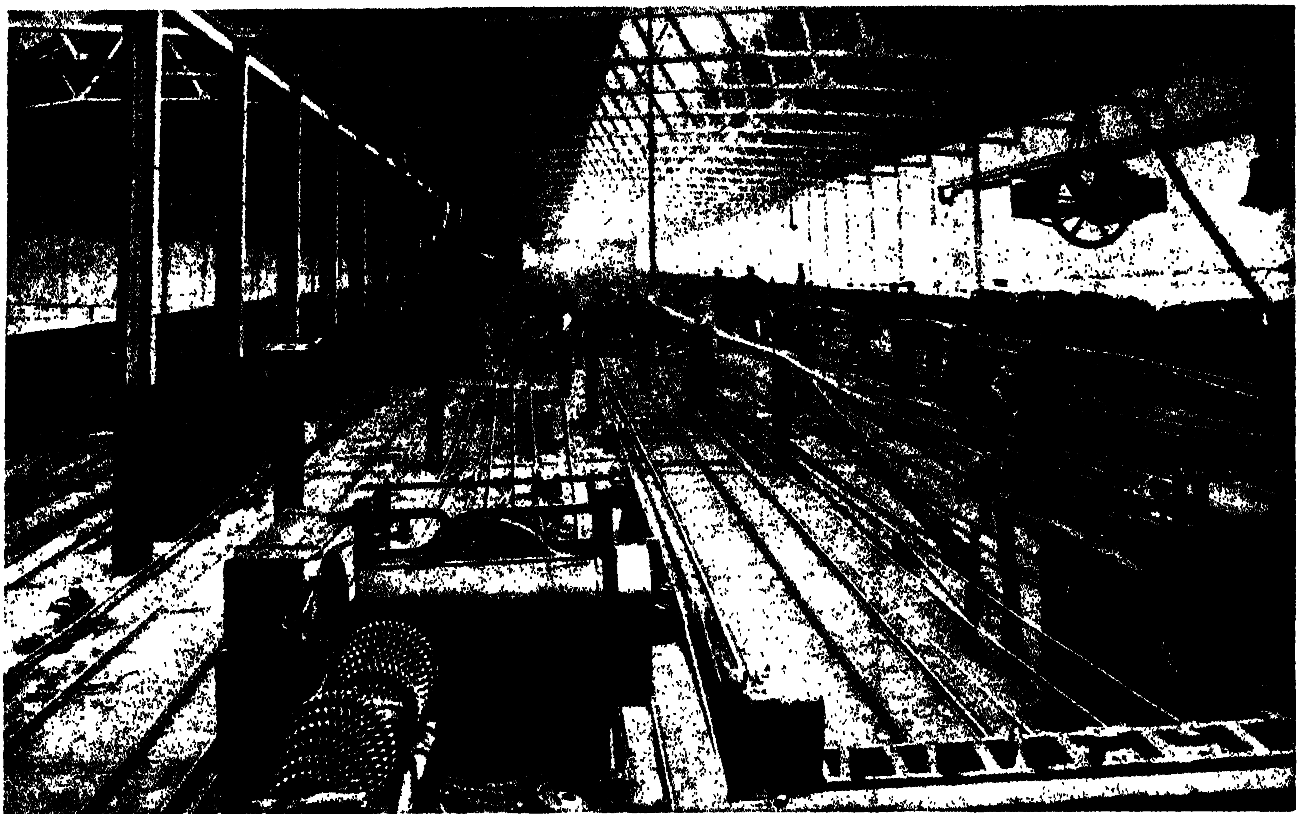


Manila and sisal are the principal fibres used in the manufacture of ropes and trawl twines to-day. The raw material, which arrives in bales weighing from 280 to 400 pounds, is first fed into a machine called a Spreader, shown on the right, where it is combed and drawn and delivered at the other side in a continuous strand of untwisted fibre known as sliver. Ten or more slivers are then fed into a machine called a Drawing and delivered in the same way as at the Spreader. The Drawing is the third machine from the right

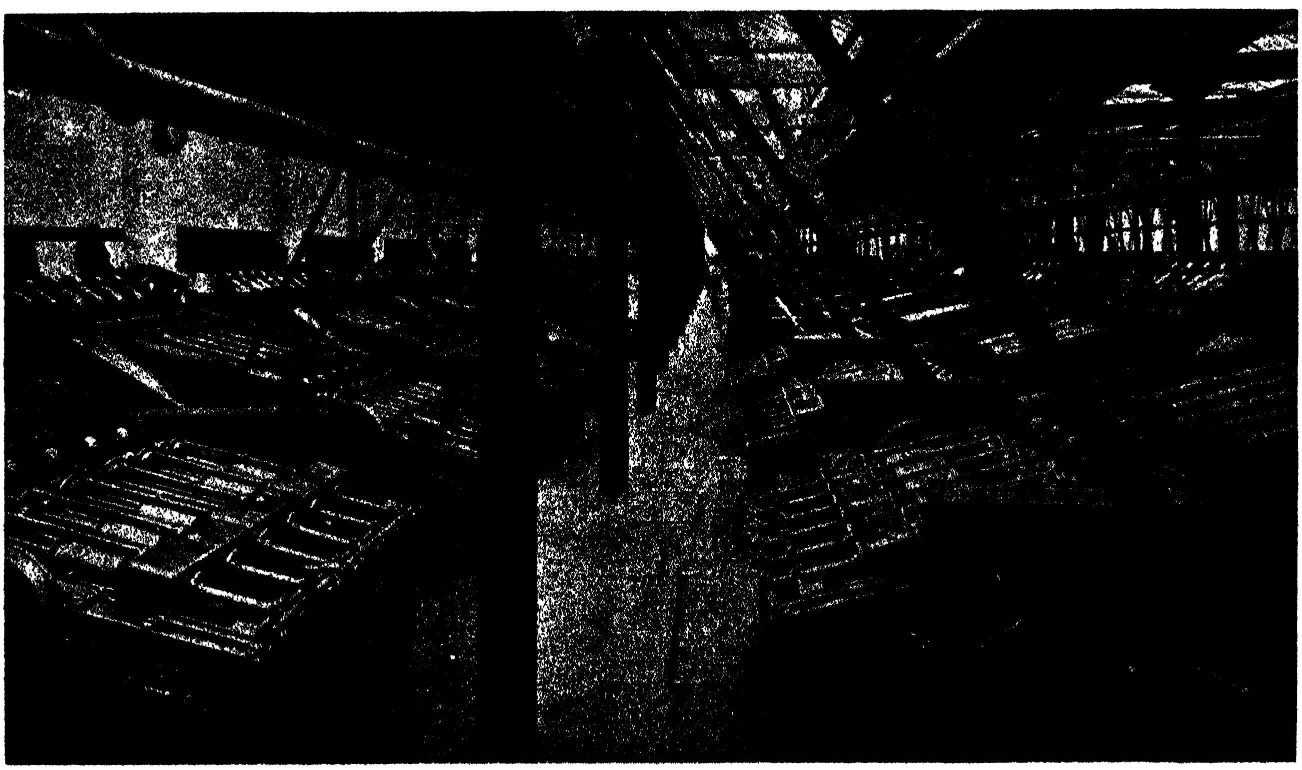


The operation of combing and drawing is repeated in five or six other machines of the same type as those shown in the upper picture, until the fibre has been doubled and drawn many hundreds of times, to insure a uniform sliver suitable for spinning into thread The sliver is then taken to the rope yarn spinning machine shown in this photograph, where it is conveyed by a series of gills to a rapidly revolving flyer which puts a twist on the sliver and runs it on to bobbins to the size of the particular thread required

THE ROPE WALK AND THE TWINE SPINNERS



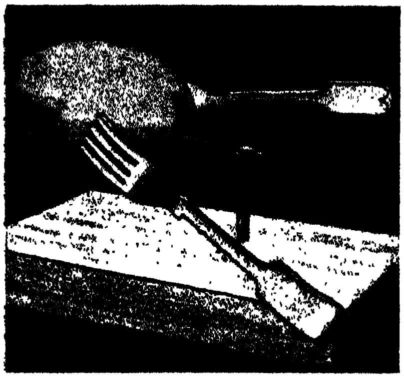
Here is an up-to-date rope walk in which tarred ropes and very large ropes are made. The various strands which are to form the rope are passed up the long building and are twisted into a rope by a rather complicated machine. Just as in smaller ropes the strands are twisted or laid into the final rope, so in a large one completed ropes are laid or twisted together to form the finished cable



For trawl twines used in the making of fishing nets, the sliver is spun over a lighter type of spinning frame, shown in this photograph. These frames are specially designed to spin finer sizes of thread than those used in the making of rope. Some of the trawl twines are made of manila and some of sisal. After spinning, the thread goes to the twine-laying department where it is wound into twine

EXPERIMENTS ILLUSTRATING BALANCE

There is no end to the experiments which we can carry out in connection with the principles of balance, and some of these are very amusing and form good entertainment for a party. Many such experiments are described on page 294, and



Balancing a potato with a knitting needle and two forks on a nail

some more are given here. They divide themselves into two classes. There are experiments in balancing objects and there are experiments in balancing ourselves.

One interesting experiment in balancing objects is shown in the first picture on this page, where we take a vegetable such as a carrot or parsnip or potato, stick a short knitting-needle into the end, and balance the vegetable by resting the end of the needle upon the head of a nail or screw driven into a block of wood.

We do this by sticking two forks into the vegetable in the manner shown in the picture, adjusting them so that the centre of gravity is brought over the head of the needle. We may have to alter the position of the forks once or twice, and move the needle to and fro a little to get the right position before attaining the success shown in the picture.

Kicking over the matchbox and returning to the upright position

Another interesting balancing experiment of this kind is to stick two forks into a cork, thrust a needle, point downwards, into the bottom of the cork, and then balance the whole arrangement on the neck of a bottle. Here, again, the forks may need a little adjustment, but it is quite an easy trick to perform.

An amusing balancing trick which may be used as a competition is to place a matchbox on the floor and try to kick it over without losing our balance. Some line, such as the edge of a carpet, is taken as a mark. Then we pace out a length equal to three of our feet by putting toe to heel. At the extremity we stand up the matchbox, then going back and toeing the line once more we endeavour to kick over the box and withdraw our foot, returning to our original position without touching the ground.

If we do this successfully the matchbox is moved a little farther out, and we continue till we cannot reach it any longer with our foot. Then somebody else takes a turn. Of course, the

Pushing a matchbox to the farthest limit without losing the balance

secret of success is to keep the upper part of the body well back, so as to retain our centre of gravity over the foot on which we are standing.

Another matchbox experiment is to toe the line and then stooping down and resting on one hand to push a matchbox as far as we possibly can. Of course, it must be pushed and not jerked. Our toes must remain still all the time, and having pushed the box as far as possible we must return to the upright position without moving our feet. Here the success of returning to the upright position depends upon not allowing our bodies to go out too far.

Still another balancing experiment carried out with a matchbox is shown in the last picture. Here we toe the line and then, putting one of our hands behind our back, we bring the other hand between our legs and push a matchbox as far as possible from the line. As in the previous experiment, the box must not be jerked, but deliberately pushed. Having placed it as far as possible we must then return to the upright position without touching the ground with our hand.

In this case the farther behind our back we can keep the disused hand the better shall we be able to keep our centre of gravity well back. When

Balancing a cork on a needle's point by means of two forks

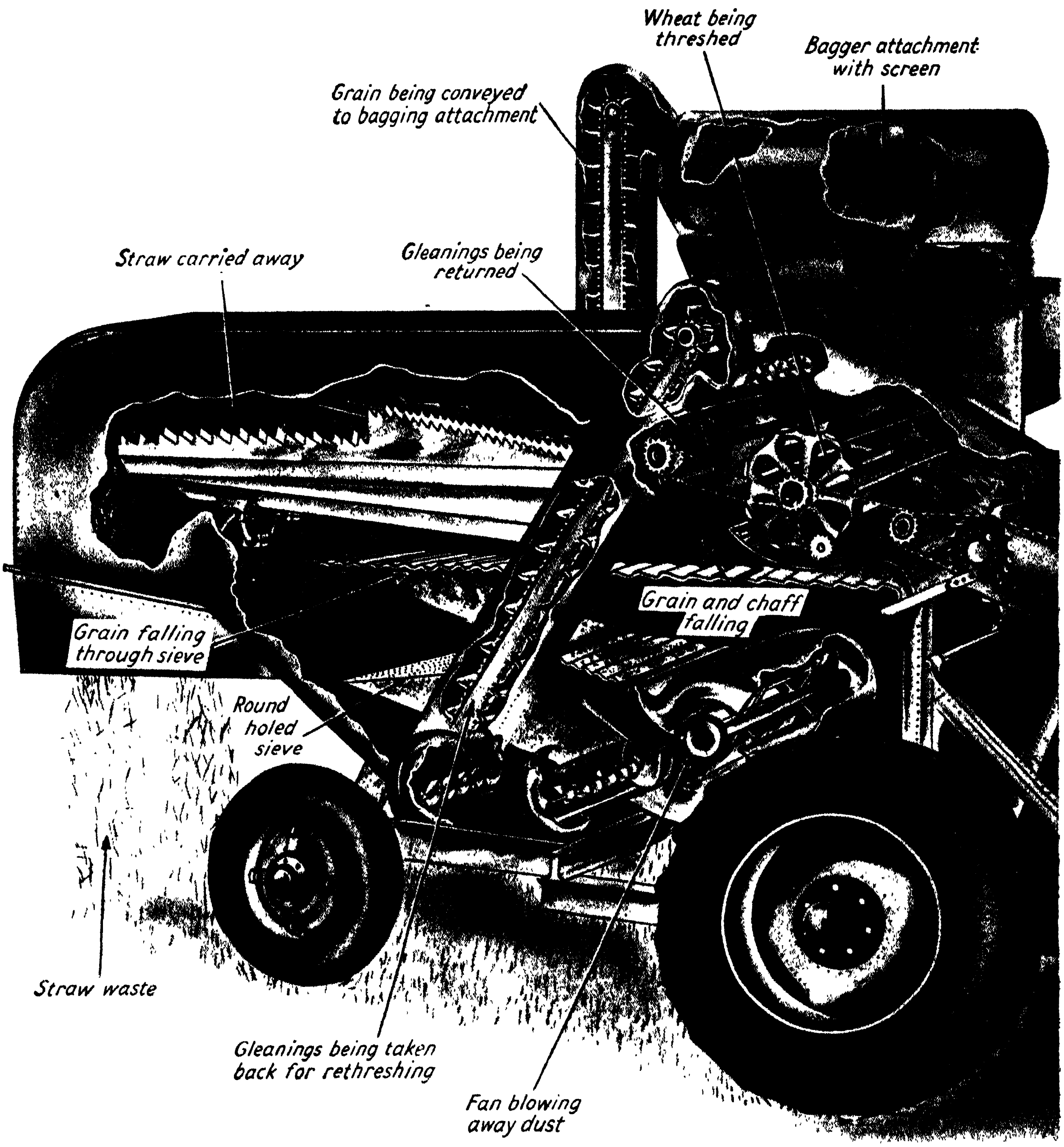
pushing the matchbox forward our hand may be on the ground, but having reached the limit we must raise the hand before endeavouring to return to the upright position.

Clever boys and girls studying the various balancing experiments which have been given on this and other pages will be able to develop a variety of new experiments for themselves.

It is, of course, always interesting to try to balance a cricket stump, croquet mallet or poker upright on the tip of our forefinger. In learning to do this we must move our finger about quickly as the upright tends to fall over, so as continually to bring its centre of gravity under the top of the stump or mallet. With practice we shall be able to support even a long object like a broom upright on our finger for a considerable period. A heavy stick is easier to support than a light one.

Another way of pushing a matchbox without overbalancing

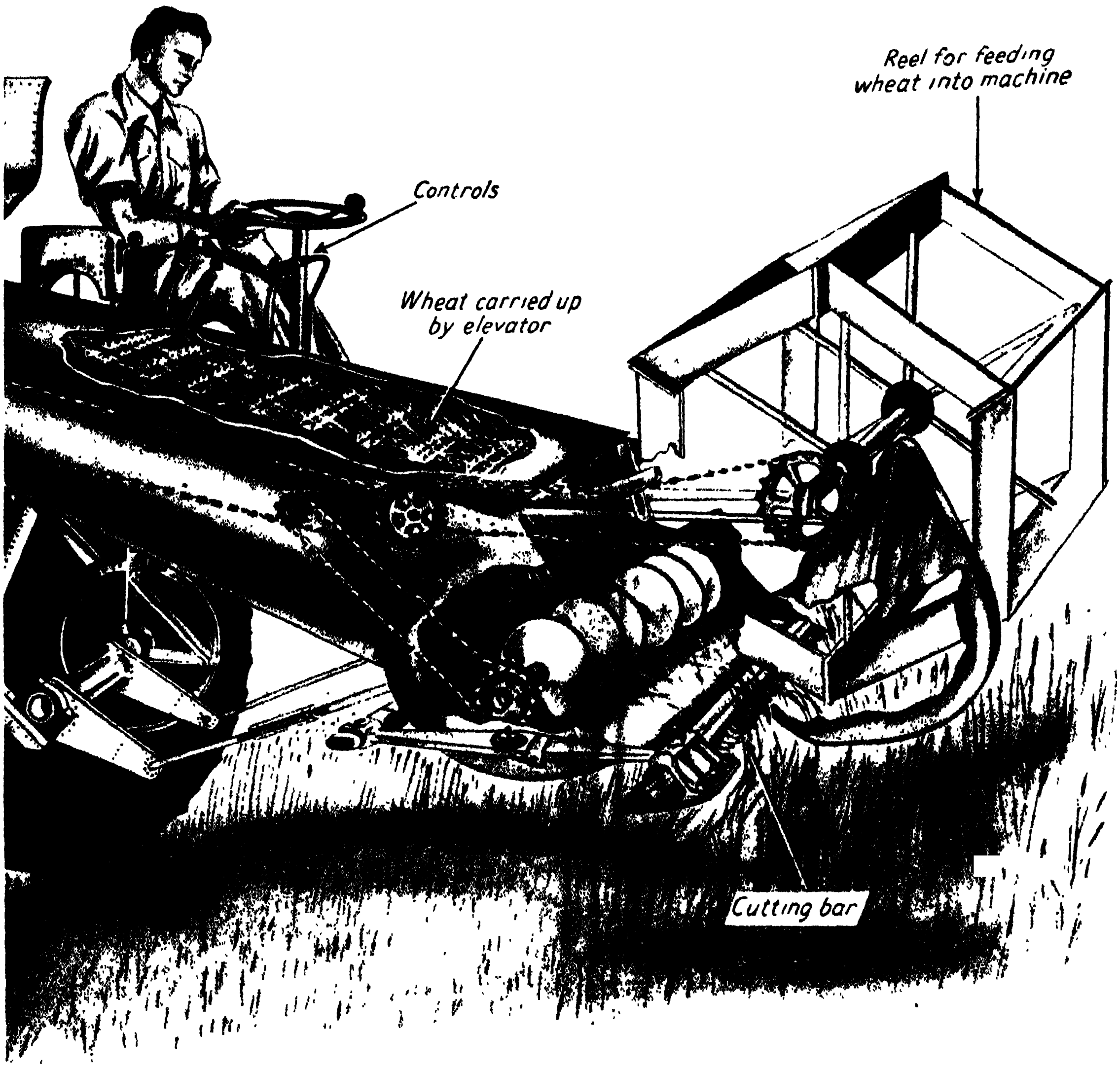
HOW THE COMBINE-HARVESTER CUTS,



In this picture we see how one of the most remarkable of all agricultural machines cuts the corn as it moves along, threshes it, separates the grain from the chaff and fills it into bags, passing the straw along to the rear of the machine. It is mounted on a tractor which also supplies the power to work the machine. As the machine travels, revolving arms pull the growing grain towards a platform, while cutters cut it off three inches from the ground. The cut stalks fall upon the platform and are carried by a canvas conveyor and elevator to a feeder-conveyor. This takes them to a spiked cylinder where, as they pass between the cylinder and concave shapes underneath, the grain is threshed out and falls upon a grain pan. This is vibrated so that the threshed grain passes across it until it reaches the end, when a blast of air from a fan blows away the chaff and other refuse known as tailings, and the clean grain falls through a sieve on to a chute and runs down into a spiral auger. It is carried by this auger to an endless band elevator which raises it and deposits it in the grain tank. The top of this elevator is shown in the drawing, and the bottom can also be seen against the spiral auger. The chaff and tailings, when blown away fall through a sieve and are conveyed by another elevator, shown in the front of the drawing, to a chute through which they fall upon the feeder-conveyor, to pass under the spiked cylinder once again. This is to insure that any grain which may have been left with the chaff shall not be lost. As the straw comes from the spiked cylinder it is thrown upon racks, of which there are three sets. These carry it to the rear of the machine, and as it passes it is combed, and any chaff and tailings fall from the rack to the sieve ready to be conveyed up for re-threshing. Every particle of grain is shaken out into troughs underneath each rack section, and it flows down the troughs on to the grain pan, by which it is conveyed through the sieve to the chute ready for filling into bags. The straw, after being thoroughly combed, is delivered at the rear of the machine. Some combine-harvesters have an attachment that automatically ties the straw into bundles, which are dropped off the end of the machine. Combine harvesters would be more extensively used in Britain but for the climate.

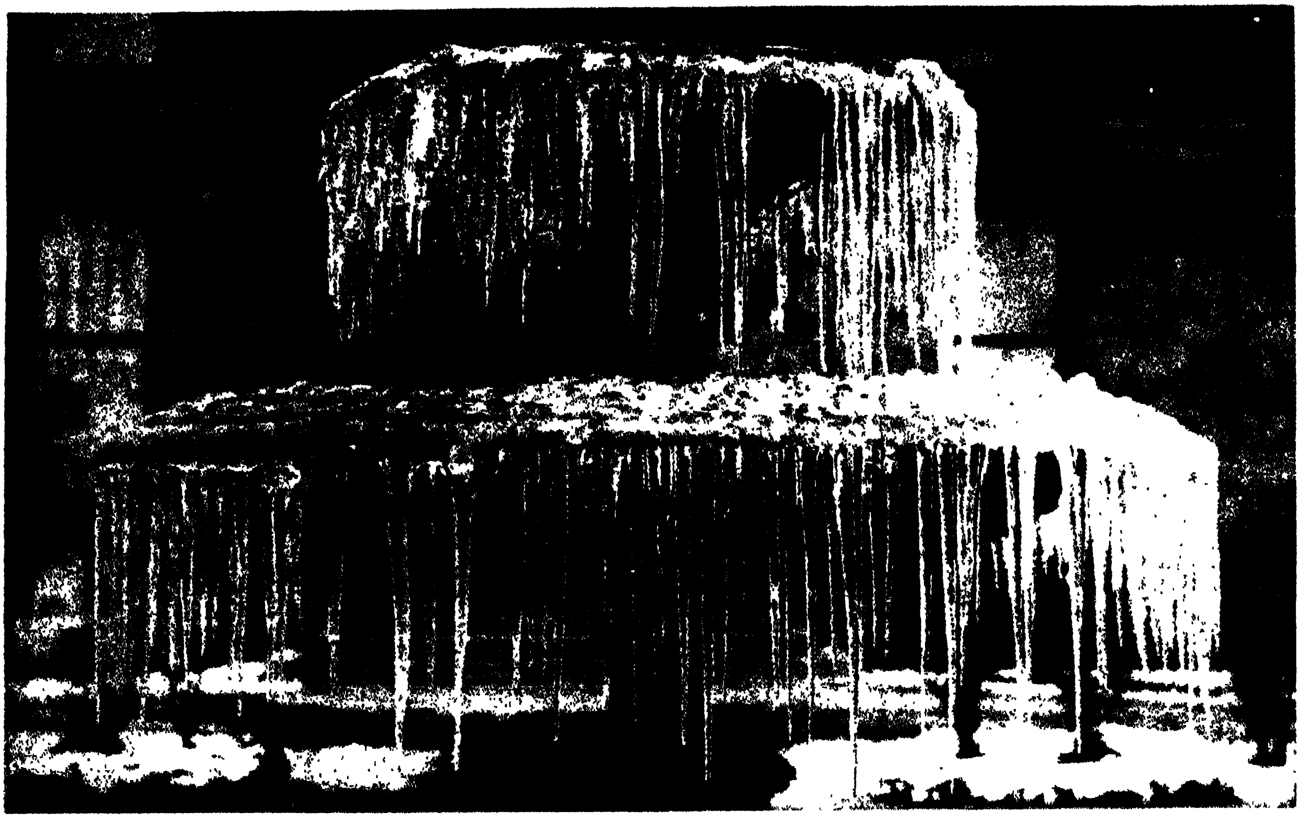
THRESHES, AND FILLS GRAIN INTO BAGS

The combine-harvester was invented in the United States of America, and its development and adoption on farms there was due to the demand of the farmers' wives, rather than of the farmers themselves. American farmers never employed a large permanent staff of hired workers and at harvest engaged bands of temporary workers for the season. These workers had to be fed and looked after by the farmers' wives, who disliked the extra work and therefore welcomed a machine that cut down their additional housework by employing fewer men at harvest time. The first combine-harvesters were towed by teams of as many as 30 horses or mules; later steam engines were used, and eventually the self-contained machine illustrated here was introduced.



In a wet season the corn may be ripe enough to cut and thresh, but the grain may be so moist that it will heat and ferment if the corn is left in bulk. Therefore the grain from farms in Britain often has to be dried artificially after it has been threshed ; and that means the expense of a grain-drier as well as a harvester. In America, grain is always dry enough to be stored immediately after milling. Some combine harvesters are drawn by a tractor, but the self-propelled type is much more efficient and labour-saving. The machine is a self-contained unit and the tractor which otherwise would be needed to haul it can be used for towing away the wagons of threshed grain. Moreover, all self-contained combines have the cutter bar in front, so that the machine can be driven straight into a standing crop. This cannot be done when the combine is pulled by a tractor, which would flatten the crop. Another disadvantage of the tractor-drawn combine is that the cutter bar is at the side, consequently a way has to be cut round the field by scythe to make a path for the tractor before the combine can start its work. On some combine-harvesters the grain is not bagged as it is threshed but flows into a bin mounted on the side of the machine. When the bin is full, it is emptied into wagons, and with skilled drivers this can be done without stopping the combine or the wagon. Many combine-harvesters have peg drums instead of beater drums. The peg drums bruise the straw which is spread on the field like a windrow as the machine moves forward. If the combine-harvester does not include a baling attachment, the straw is collected by hay-sweeps and taken to a stationary baler, or, on very highly-mechanised farms, pick-up balers are used, which are themselves combined machines, because they load and bale the straw in one operation. On some farms the bruised straw is allowed to lie on the ground after it falls from the combine-harvester and is later ploughed in as manure when the stubble field is ploughed for the next sowing

HOW LONG CAN AN ICICLE GROW?



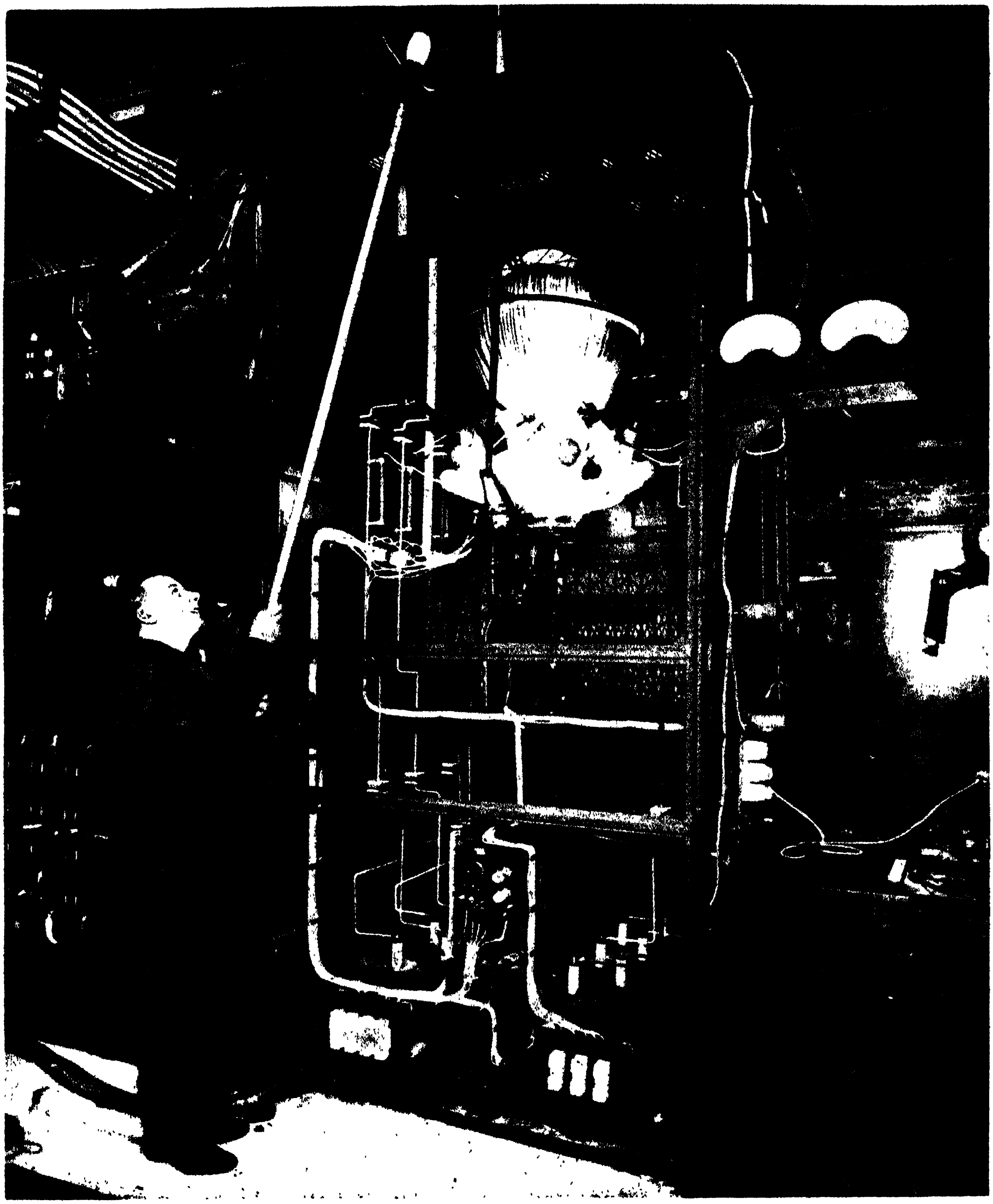
Here are some very long icicles which were formed on a fountain in London. It is not often in the South of England that the frost is hard enough and prolonged enough to produce such icicles, but in cold regions like the Upper Alps and the Arctic some very big icicles are formed. Often those hanging over the side of a crevasse on a glacier are thirty feet or more in length

These icicles were formed on the fireman's hose at a great fire in London during an intensely cold night. The heat given out by a blazing building is great, but as soon as the flames die down the surrounding atmosphere is little affected. When we see festoons of icicles as shown here we can appreciate Longfellow's expression in describing the trees in winter as having their "beards of icicles."

A TYPICAL LANDSCAPE ON THE MOON

This wonderful photograph of a part of the Moon's surface was taken with the hundred-inch telescope at Mount Wilson Observatory, in California. It shows, in the centre, the great crater of Copernicus and the surrounding country, which is studded with hundreds of smaller craters similar in form. Copernicus is more than fifty miles across, or as far as from London to Brighton. The rampart all round rises 13,000 feet above the inside plain, in the centre of which rise several mountain peaks. Whether these so-called craters are really of volcanic origin or not, they certainly have that appearance. As Professor Jacoby says, it is as though the crater wall had been formed by a shower of volcanic material ejected from a centre and falling in a circle around it. The central peaks may have resulted from a final outburst of the volcanic discharge, after this had become too feeble to throw the lava from the centre.

THE GIANT BULB OF THE ELECTRIFIED RAILWAY



Here is one of the biggest electric bulbs in the world. It is used on electrified railway lines to convert alternating current into direct current. Alternating current flows in wave formation, that is, it surges back and forward along its conductor, while direct current does not surge. By passing the alternating current through this bulb the wave is flattened out and the current becomes nearly direct. Direct current is for various technical reasons more suitable than alternating current for use on electric railways where distances are comparatively short. The bulb takes the place of the older type of mechanism for this work, which was known as a rotary converter. The Southern Region of British Railways has hundreds of these bulbs on its system. As the electric load or amount of current increases, the light given out by the bulb becomes brighter

THE WONDERFUL WEB OF LIFE

All living creatures are bound up in a web of life, and what affects one directly or indirectly affects another. In these pages we read about some very interesting examples of this dependence of one form of life upon another and how the various strands of the web are joined up with each other

We have seen in recent years how the different nations are bound together, and that trouble affecting one section of the human race in some remote part of the Earth is not a matter of mere local importance, but reacts on quite different peoples on the other side of the world.

Civil war and famine in China mean more unemployment and fewer pleasures for working people in England and America. If the Chinese are so poor that they cannot buy English and American goods, not to mention those of other nations, then English and American workmen are very soon short of work.

It has been said, with a good deal of truth, that if the Chinese could be induced to wear their shirts two inches longer, the problem of unemployment among the cotton workers of Lancashire would be solved.

But it is not only in human affairs that the web of life is so closely woven. We find it throughout nature, and anything that affects one group of creatures abnormally is sure to upset the balance of nature and lead to strange and often serious happenings among other groups of living beings.

Here is a striking example which happened some years ago in South America. During the summer season there was more than the usual amount of rain, and as a result the wild flowers, instead of being parched and withered by the hot sun, as usual in those parts, were able to bloom throughout the summer. These attracted an exceptional number of humble-bees, and in the wake of the bees came an enormous number of mice, which live very largely upon these bees.

The provision of such generous supplies of food enabled the mice to increase at a far more rapid rate than was common in that district, and by the end of the summer it is said "the earth so teemed with them that one could scarcely walk anywhere without treading on mice; while out of every hollow weed-stalk lying on the ground dozens could be shaken."

Exhausting the Food Supply

Of course, the dogs and cats that lived in the neighbourhood preyed upon the mice, and it is said that even fowls became birds of prey for the time being. But these were too few to make any impression on the mice, and soon new birds arrived in remarkable numbers, and fed upon the mice.

The result of all this was that in a short time, instead of there being more mice than usual in the country, there were far fewer, for not only did the birds prey upon them and reduce their numbers, but it was not long before the mice had eaten up all the humble-bees, and so destroyed their own food supplies. Later the storks and owls left the country, and the few mice that remained could then multiply, and after a year or two the balance of nature was restored.

Charles Darwin gives us another very interesting example of the dependence of one form of life on another. We hardly think of there being any connection between cats and clover, for cats are carnivorous animals, and do not eat clover. "I have found from experiments," he says, "that humble-bees are almost indispensable to the fertilisation of the heartsease, for other bees do not visit this flower. I have also found that the visits of bees are necessary for the fertilisation of some kinds of clover—thus one hundred heads of red clover produce 27,000 seeds, but the same number of protected heads produce not a single seed. Humble-bees alone visit red clover, as other bees cannot reach the nectar. Hence we may infer as highly probable that if the whole genus of humble-bees became extinct or very rare in England, the heartsease and red clover would become very rare, or wholly disappear." For the purposes of his experiment Darwin protected the heads of the clover to prevent the bees reaching them.

It is a fact that the red clover imported by New Zealand did not bear fertile seeds until humble-bees were

Here are a number of links in the chain of life. The clover needs the humble-bee to fertilise it, but mice prey on the humble-bee's nest, and would exterminate the insect were it not for the cats which prey upon the mice. By keeping down the number of mice the cats help the clover plants to thrive

also imported. Darwin goes on to point out that the number of humble-bees in any district depends in a great measure on the number of field-mice which destroy their combs and nests, and investigations have shown that probably two-thirds of the humble-bees all over England are thus destroyed.

Now, as Darwin goes on to explain, the number of mice is largely dependent on the number of cats, and it is a fact that near villages and small towns the nests of humble-bees are more numerous than elsewhere, a state of things which is attributed to the number of cats which destroy the mice. It is clear, therefore, that next year's crop of red clover depends upon the number of humble-bees in the district, and that varies with the number of field-mice, which number, in turn, depends upon the abundance of cats.

Dr. E. J. Allen, a distinguished marine biologist, tells us that there is a close connection between the price of mackerel in London and the amount of spring sunlight off the Cornish coast. The more sunshine there is in May, he says, the more mackerel there will be at Billingsgate, and, of course, when the supply is abundant, the price is low.

Minute Life

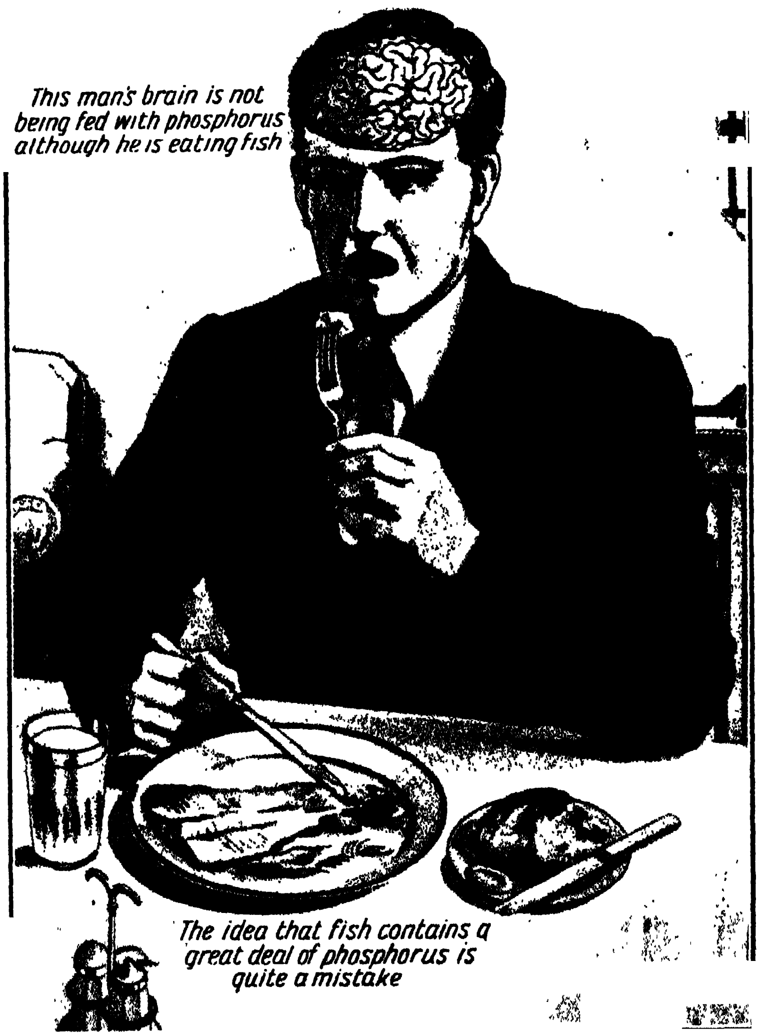
This is how the two apparently unconnected facts are woven together. In spring the mackerel feeds largely upon plankton, a name given by scientists to minute floating organic life found at various depths in the ocean. Plankton—the word meaning wandering—consists of both animal and plant life. Animal plankton includes minute jelly-fishes and crustaceans, radiolaria, foraminifera, and other lowly creatures, while plant plankton is made up of diatoms, very small forms of algae, and so on.

Now the plankton that the mackerel feeds on in spring-time is made up of small crustaceans known as copepods, a name meaning oar-foot, and given because the creatures move about by means of little limbs like oars or paddles.

Copepods, in their turn, feed upon the vegetable plankton, such as diatoms, as well as upon more lowly animals called infusoria. The production and development of those forms of plankton are dependent very largely on the amount of light which falls upon the sea. When there is an abundance of sunshine the diatoms and infusoria multiply. The copepods then have plenty of food, and they in turn, increase, and the mackerel, being well supplied with sustenance, also increase.

Sir J. Arthur Thomson, the distinguished scientist, once declared that there is a connection between mud and clear thinking. "To keep a famous inland fish-pond from giving out," he says, "some boxes of mud and manure were placed at the sides. Bacteria, the minions of all putrefaction, worked in the mud and manure, making food for minute infusoria which multiply so rapidly that there may be a million from one in a week's time. A cataract of infusoria overflowed from box to pond, and the water-fleas and other small fry gathered at the foot of the fall and multiplied exceedingly. Thus the fishes were fed, and as fish flesh is said to be good for the brain we can trace a nexus from mud to clear thinking. What was in the mud became part of the infusoria, which became part of the crustaceans, which became part of the fish, which became part of the man."

It must be pointed out, however, that a great authority on diet, Dr. Robert Hutchison, denies that fish is a specially valuable food for the brain. This idea came about through two curious errors. Another scientist, Dr. Buchner, once declared that "without phosphorus there is no thought." But this is only true in the sense that the brain contains phosphorus and, of course, without the brain there can be no thinking. "But," says Dr. Hutchison, "it has never been shown that an increased supply of phosphorus in the food is specially favourable to mental effort."



The popular idea that fish contain a great deal of phosphorus, and that to eat food containing phosphorus is good for the brain, is quite mistaken. Fish have no unusual amount of phosphorus in their composition, and even if they had this phosphorus would not reach the brain

A Mistaken Idea

The other error which gave rise to the belief that a fish diet increases brain power was begun by the Swiss naturalist, Agassiz, who was responsible for the statement that fish is specially rich in phosphorus. There is, however, no justification for the statement.

Sir J. A. Thomson's remarks, however, about the connection between mud and clear thinking, are perfectly true, for fish is a very good food, and we must be properly fed if we are to think clearly.

Professor James Ritchie has given other examples showing how Nature is linked up. He explains that sunny weather and a good season in Canada in one year means that four winters later many ladies will be wearing fur coats in Aberdeen. He also explains that the extermination of the Greenland whale brought about by the demand for balena or whalebone for busks for ladies' stays in the days of Queen Victoria, led to the disappearance of frogs in the neighbourhood of London. The links in these chains of life are set forth on page 801. It will thus be seen that St. Paul's statement that "none of us liveth to himself and no man dieth to himself" has a very wide application.

THE EARTH BENEATH US AND THE AIR ABOVE

EVER since men have stood on the earth they have wondered what the inside of the world is like; just as they have wanted to know about the atmosphere that surrounds the earth. And it is a curious fact that science has found out much more about the atmosphere hundreds of miles above us than it has discovered about the earth a few miles beneath our feet.

Rockets have been fired to a height of 250 miles, but no one has yet managed to dig deeper into the ground than three or four miles.

It is, however, known how long earth vibrations take to pass through different kinds of rocks and minerals, and by estimating the time taken for an earthquake tremor to pass from one side of the world to another scientists have worked out the kind of material that we should find deep in the earth if we could dig down.

We may take it as almost certain that our world consists of a central core surrounded by five shells. The central core, called the centrosphere, is probably some 4,000 miles in diameter and is believed to consist of nickel and iron ore in a soft or partly liquid state.

Surrounding the centrosphere is what is called a layer of transition or the barysphere. It is nearly 2,000 miles thick and thought to consist of iron, nickel and rock, very tightly packed together and having a high temperature. Outside the barysphere is another layer of rock, about 1,000 miles thick, called the basaltic shell. Then comes another layer of rock called the silicate shell; surrounding the silicate shell is the lithosphere, made up of granite rock 25 to 30 miles thick and surrounding the whole earth as a crust.

When we come to describe the atmosphere surrounding the earth, there are plenty of proved scientific facts to help us to know what it is like and what it is composed of.

There are three layers of atmosphere. Closest to the earth is the troposphere; next, the stratosphere; and then the ionosphere.

About 80 per cent of the gases making up the whole atmosphere are packed into the troposphere, which reaches a height of ten miles at the equator. In the troposphere are most of the air currents and clouds responsible for our weather.

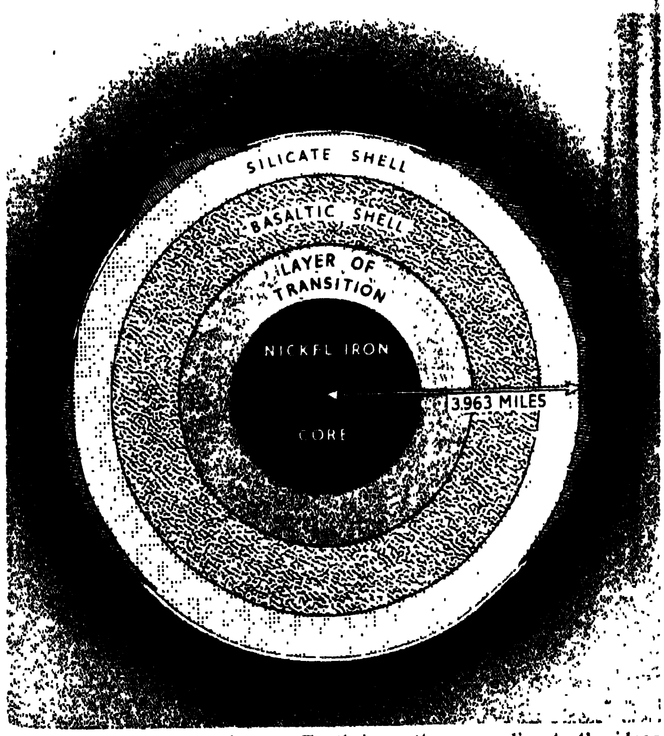
Extending to a height of about 50 miles above the troposphere, the stratosphere is brownish-black in colour, and in it the moon and all the stars are visible even by day.

Twenty-five miles up in the stratosphere is a thin strip of gaseous mixture called ozone, without which life on earth would be impossible, for it absorbs most of the ultra-violet radiation from the sun. A little ultra violet radiation is essential to life, but too much of it would kill all living things.

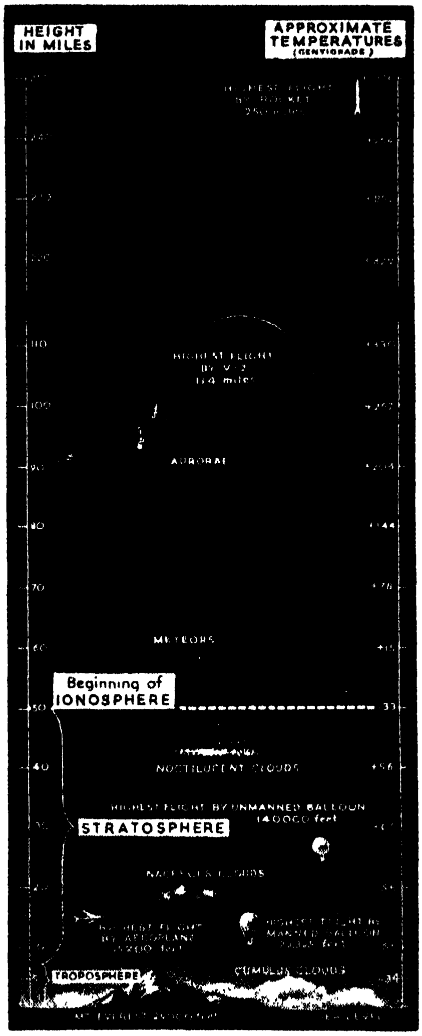
Fifteen miles up in the stratosphere are the nacreous clouds, masses of ice crystals with a sheen like that of mother of pearl. Nearly ten miles above these are the noctilucent clouds, vapoury banks of fine dust.

At a height of some 60 70 miles above the earth is the beginning of the ionosphere, which is electrified by radiation from the sun. Nothing was known about the ionosphere until the invention of radio, when it was discovered through its property of reflecting radio waves back to the earth.

No one has yet discovered how far upwards the ionosphere extends. Its height was at first thought to be not more than 100 miles, but scientists now believe that it may extend for 18,000 miles above the earth. If we could rise through the ionosphere we should find the air becoming thinner and thinner until at last we passed beyond the atmosphere into an airless region of cosmic dust and atoms of gas.



Here is a diagram showing the Earth in section according to the ideas that scientists hold about what is inside it.



The details shown on this diagram of the atmosphere surrounding our world are based on readings registered on instruments carried by rocket to a height of 250 miles. Also shown are the heights reached by different kinds of aircraft. The scale on the left shows the temperatures at the heights marked on the right-hand scale.

At these great heights there would be utter silence and eternal darkness. Life would be impossible because there would be no air to breathe.

Not the least wonderful thing about the atmosphere are the variations in temperature as height increases. In the lower stratosphere the temperature is − 67 degrees centigrade; the temperature then rises to 153 degrees centigrade at 30 miles; drops to 59 degrees centigrade at 60 miles; and thereafter rises to 1,898 degrees centigrade at a height of 250 miles.

THE APE THAT MOST RESEMBLES MAN

The chimpanzee, one of the man-like apes whose home is in the forests of Central Africa, has such amusing and attractive ways that one cannot help feeling an affection for it. It is certainly one of the most popular of all the inmates of the London Zoo; but, unfortunately, like the other man-like apes, it is slowly disappearing from the world. Here are many interesting facts about this intelligent and very human animal

SCIENTISTS tell us that of all the man-like apes, the chimpanzee is nearest to man in bodily structure. Certainly in its appearance and ways it is most human. Its face has quite a kindly and human expression, it is affectionate to its kind, and it can be taught easily to do all manner of things that human beings do. It will sit at a table and eat and drink like a child, it loves fun and play and when dressed in human garb, suggests its kinship with ourselves.

The chimpanzee is a social animal, and in the wild state lives in family parties numbering from twelve to forty. It is sad to think that as man encroaches upon the territory occupied by these interesting apes their numbers get fewer and fewer, and as Sir Arthur Keith has said, when the great African forest belt disappears the chimpanzee will go with it. At the present time it is estimated that the chimpanzee population of Africa, its native home, does not exceed 150,000.

Men of science place the chimpanzee first in order of intelligence among the man-like apes, although its brain is less in size than those of the orang-utan and gorilla. At its birth the chimpanzee is only about one-third the weight of a human baby. Although the human baby does not get its first teeth till it is six months old or more, the baby chimpanzee begins to cut its teeth at two months, and has all its milk teeth when it is a year old.

Two young chimpanzees at the London Zoo looking at their visitors

Unlike the human baby, the chimpanzee can begin to look after itself at the age of two years, and it is quite grown up when it is fourteen. It then weighs from eight to twelve stones, resembling man in this respect, but its body is longer and its lower limbs shorter. It is not often that a chimpanzee is more than four feet eight inches high. Sir Arthur Keith tells us that in general wear of the body a chimpanzee is as old in its fortieth year as a man in his seventieth.

The chimpanzee has been known in Europe for more than four centuries, and it is among the most popular of all animals in zoological gardens. It requires great attention to keep it healthy, but nowadays zoos, like that in London, are able by scientific treatment, to keep the animals alive for years.

The hands and feet of the chimpanzee are more slender than those of the gorilla, and as in the case of man, the middle finger is longer than any of the others.

Chimpanzees inhabit Western and Central Equatorial Africa, and range over a large extent of country. They are forest dwellers, though in one district they are found in the mountains. In the wild state they live upon fruits, and are strictly vegetarian, but in captivity they take quite kindly to a mixed diet in which animal food has an essential part.

In their native home the parties of chimpanzees are always on the move in order to find fresh feeding grounds. They make a loud cry which can be heard sounding through the forests at all hours of the day and night. Their voice travels a great distance, and many chimpanzees will be calling at one time. This ape remains a good deal on the ground, but it climbs trees for the sake of obtaining the fruits or to rest. It builds rough nests high up in the trees, where the females and young sleep, while the male takes up a position beneath the shelter so as to protect its family.

Scientists declare that the intelligence of many chimpanzees is equal to that of a child a few months before emerging from the period of infancy, and is thus far higher than that of any other mammal except man.

The chimpanzee, when moving about, walks on all fours. It is covered with hair, the prevailing colour of which is black.

When necessary the chimpanzee can be quite fierce, and it is a powerful animal. It generally flees at the sight of man, but if its retreat is cut off it will turn and attack fiercely, when it is an exceedingly awkward customer to deal with. Dr. Livingstone says that the chimpanzee kills the leopard occasionally by seizing both paws and biting them. The lion, however, kills the chimpanzee at once, but does not eat it.

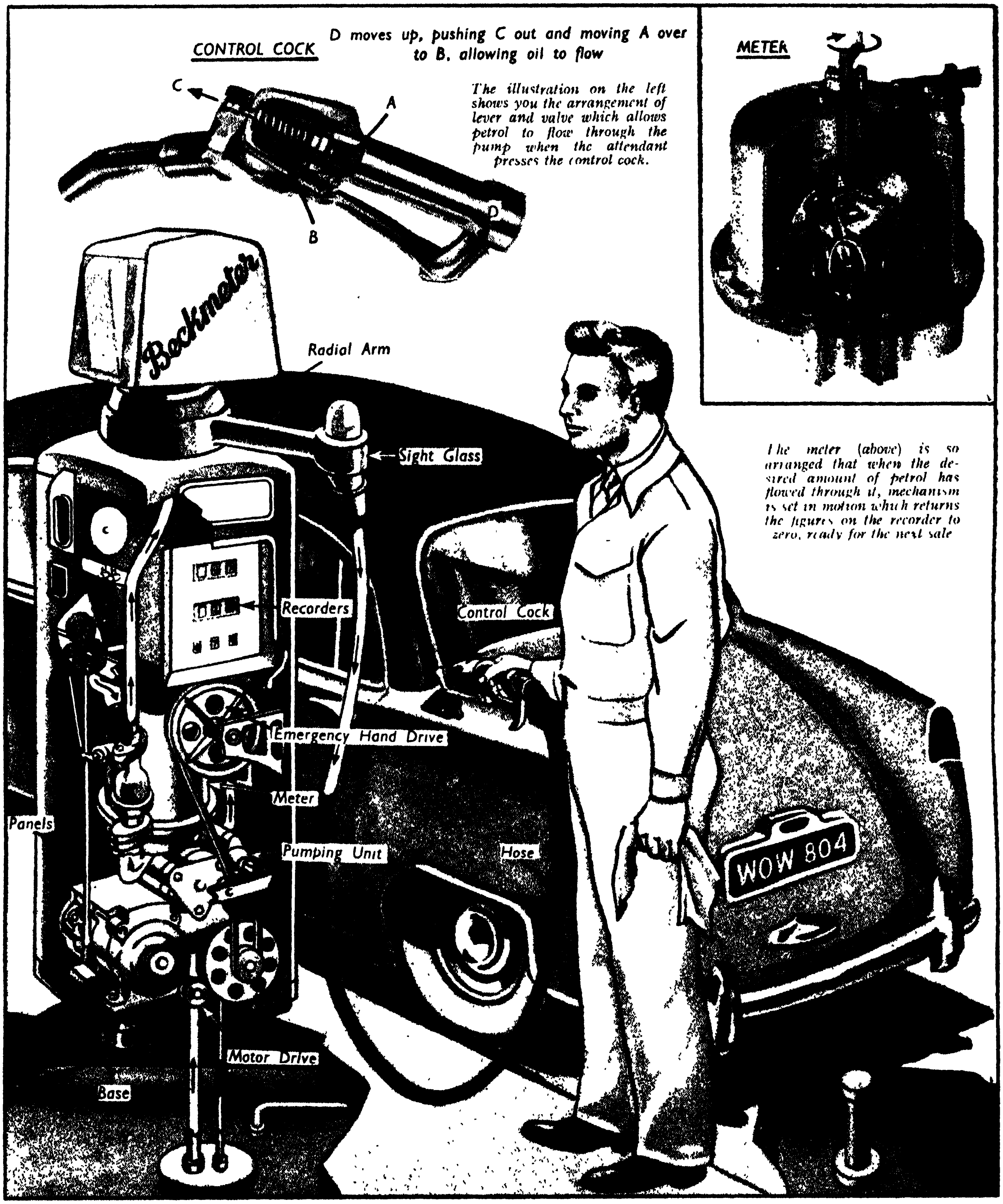
When the chimpanzee travels on all-fours it generally supports itself on the backs of its closed fingers and not on the palms of its hands. It also goes sometimes on the soles of its feet and sometimes on its closed toes.

THE MOST HUMAN OF THE MAN-LIKE APES

The chimpanzees are the most human of all the man-like apes. Scientists give the chimpanzee first place in order of intelligence among mammals, and it can be trained to dress and act and eat like a human child. It also has a marvellous power of facial expression, as we can see in the case of these two chimpanzees which are chattering together. The movements of their lips are particularly amusing.

Chimpanzees are natural clowns, like this one balancing a grape on its nose. Once a chimpanzee has learned a trick it loves to repeat it, particularly if it can perform before an appreciative human audience.

ELECTRIC PUMP THAT DELIVERS AND PRICES PETROL

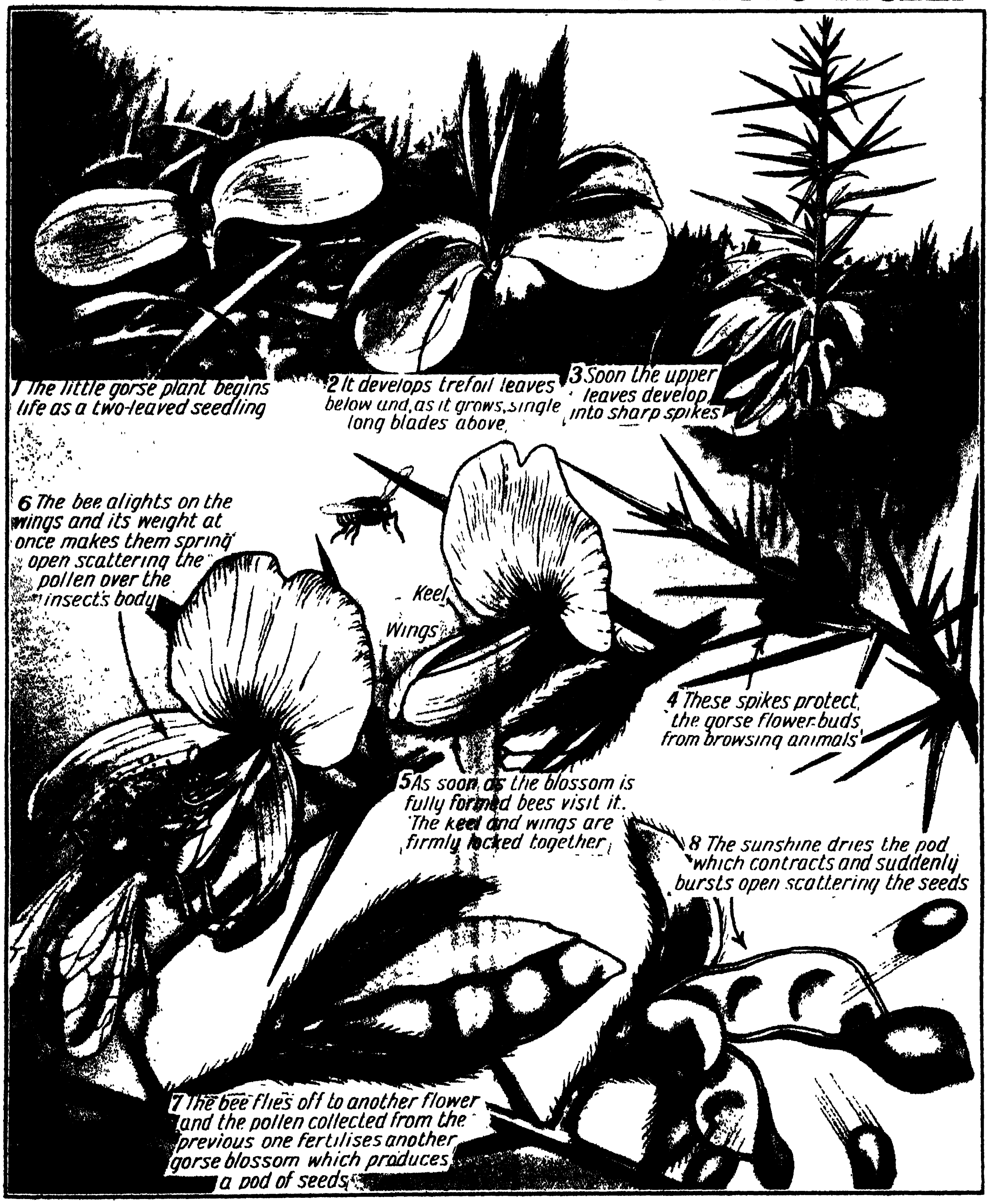


The illustration on the left shows you the arrangement of lever and valve which allows petrol to flow through the pump when the attendant presses the control cock.

The meter (above) is so arranged that when the desired amount of petrol has flowed through it, mechanism is set in motion which returns the figures on the recorder to zero, ready for the next sale

In this drawing we see the inside of an electric petrol pump. The attendant turns a knob which sets the figures on the centre line of the recorder to the number of gallons required. He then switches on a motor which operates a rotary pump, and draws petrol from a main tank, through a filter, and passes it up a pipe to a separating tank, where all air and gases are eliminated. The petrol flows to a measuring meter, where by pistons and valves the correct quantity as set by the dial is regulated. From the meter the petrol goes past a sight glass to a hose-pipe, and so to the car. When the required number of gallons has been pumped into the car tank, the total price of the petrol delivered is indicated on the lower line of the recorder. This is done automatically, and the mechanism of the computor can be adjusted to make the correct charge irrespective of changes in the price of petrol. In the top right-hand picture is a detailed drawing of the valves in the meter which work to and fro, first drawing petrol into the inlet pipe, and then discharging it to the hose. The arrows indicate the direction of the petrol through the meter, and the consequent movement of the recorder mechanism.

HOW THE GORSE PLANT PROTECTS ITSELF



In these pictures we see the life-story of that familiar plant the gorse or furze. From the seeds which are scattered on the ground a little plant begins to sprout. At first it is a seedling with only two leaves, and these soon become trefoil—that is, they are divided into three parts. As the plant grows more leaves form, but these are long blades, quite unlike the trefoils. The plant increases in height, and as it does so the leaves develop into sharp spikes, which act as a protection to the plant and prevent browsing animals from feeding upon it. Flower buds form among the spikes, and these develop into blossoms with a keel and wings, inside which are the pollen-producing parts of the flower. A bee alights on the wings and its weight causes them to fly open, scattering the pollen over the bee. The insect flies off to another plant, and the pollen from it fertilises the female part of that flower, so that seeds can be produced which form in a pod; and when the pod becomes dry it springs open and the seeds are scattered round about on the ground, starting the story all over again and enabling the plant to survive in the struggle for life

HOW SUN STORMS CAUSE THE AURORA

The Aurora, that marvellous display of flashing lights in the polar regions, which often takes on fantastic forms and is sometimes seen faintly in the British Isles, is caused by streams of energy poured out by the Sun. This energy is in the form of particles like electrons and they are shot out violently from the sunspots, where titanic fiery storms are going on at the Sun's surface. They travel across Space with the speed of light, and when the Earth is within their line of fire, rich auroral displays are seen. The Earth, being a magnet, these particles of energy are attracted to the North and South magnetic poles, as shown in this picture. At such times the compass, the telegraph and the wireless are affected. When seen in the North we call the display the Aurora Borealis or Northern Lights, and when seen in the South it is called the Aurora Australis, or Southern Lights

WONDERS OF THE SKY

THE MAGNIFICENCE OF THE AURORA

Many boys and girls, as well as grown-up people, have seen displays of the Aurora Borealis, or Northern Lights, in England, for on an average two displays are witnessed every year in the south of England, and about twice as many in the North, while far up in Scotland forty or fifty auroras are seen in twelve months. But these displays are feeble compared with the magnificent auroras seen in the polar regions. Here we read about the real cause of this striking phenomenon

THE Aurora Borealis, sometimes called the Northern Lights, is often seen in the British Isles, but it is very faint there compared with the magnificent displays that are seen in the polar regions.

The aurora takes a great variety of forms, and these have all been given particular names by scientists. Its colour also varies a great deal, being sometimes white and at other times yellow, red, green or blue. If the display is brilliant three colours may be seen, the lower part being red and the upper part green, with yellow in between.

Then, again, the rays of light that project like spokes are sometimes stationary and sometimes flash and move and cross one another, or shoot up into the sky and then recede again.

Curiously enough, the aurora is not most brilliant at the Pole. As we go north the number of displays and their brilliance increase, but if we continue travelling towards the Pole, there comes a point when the auroras decrease once more.

Immense Heights

A great deal of attention has been given to the aurora in recent years, and men of science have studied it from many points of view. Its height, for instance, has been measured by making observations of a display from two definite points a certain distance apart. The height varies a great deal, and seems to range from fifty to six hundred miles.

Farther north the aurora seems to approach the surface of the Earth, and some observers declare that displays have been seen at a height of not more than a mile. In the northern regions a crackling sound has been heard while the display has been going on.

It is now generally agreed by men of science that the aurora is an electrical or magnetic phenomenon, and as the number of auroras corresponds very closely with the abundance or otherwise of sunspots, it is generally agreed that the displays originate in the Sun. They are believed to be due to the ejection of particles like electrons from the sunspots. But there would seem to be something more than this about the aurora, for a spectrum of its light has suggested that it was gaseous, and a green line in the spectrum reveals an unknown gaseous element which is supposed to be closely allied to, if not actually identical with, krypton, a rare element found in the atmosphere.

Professor Vigard of Oslo has produced a display similar to the aurora in a laboratory. He subjected nitrogen gas, which is the chief element of our atmosphere, to intense cold, until it was frozen into fine crystals at a temperature of about 378 degrees below zero, Fahrenheit. He then bombarded these frozen crystals with electric rays, and the light that they gave out, when observed through the spectroscope, showed the mysterious green line that had been seen in the spectrum of the aurora.

A remarkable display of the Aurora seen in Alaska

That there is a close connection between the displays of the aurora, the variation in the number of sunspots, and the variation of the magnetic needle, the diagram on page 808 will make clear.

It has been said quite truly that if a bright aurora is shining in Stockholm, or Reikjavik in Iceland, the compass at Greenwich or Paris Observatory, hundreds of leagues off, is affected by it.

The auroral display is witnessed in both the Arctic and the Antarctic. In the northern regions it is called the Aurora Borealis, or Northern Aurora, while in the south it is called the Aurora Australis, which means the Southern Aurora.

There seems no doubt that the reason why the displays are manifested in the north and south polar regions is that the particles of energy shot out by the sunspots are attracted to the regions of the north and south magnetic poles.

A Wonderful Phenomenon

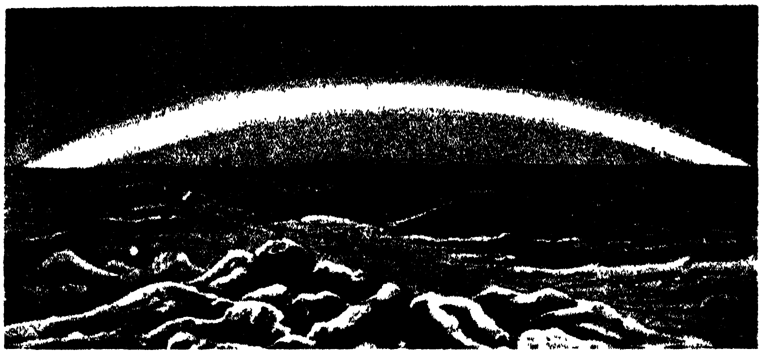
How very magnificent and varied these displays in the higher latitudes are is clear from the descriptions of eye-witnesses. One traveller who witnessed many displays in Spitzbergen has given the following account of the wonderful phenomenon:

"At times they are simple diffused gleams or luminous patches; at others quivering rays of pure white which run across the sky, starting from the horizon as if an invisible pencil were being drawn over the celestial vault; at times it stops in its course, the incomplete rays do not reach the zenith, but the aurora continues at some other point; a bouquet of rays darts forth, spreads out into a fan,

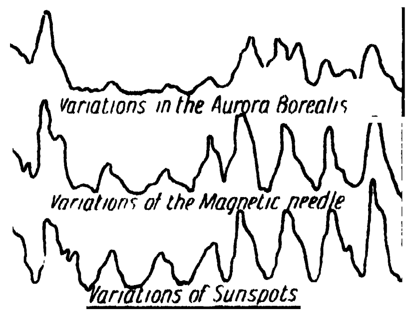
then becomes pale and dies out.

"At other times long golden draperies float above the head of the spectator, and take a thousand folds and undulations as if agitated by the wind. They appear to be but at a slight elevation in the atmosphere, and it seems strange that the rustling of the folds, as they double back on to each other, is not audible. Generally a luminous bow is seen in the north; a black segment separates it from the horizon, its dark colour forming a contrast with the pure white or bright red of the bow, which darts forth the rays, extends, becomes divided, and soon presents the appearance of a luminous fan, which fills the northern sky, mounts nearly to the zenith, where the rays, uniting, form a crown, which, in its turn, darts forth luminous jets in all directions.

"The sky then looks like a cupola of fire; the blue, the green, the yellow, the red, and the white vibrate in the palpitating rays of the aurora. But this brilliant spectacle lasts only a few minutes; the crown first ceases to emit luminous jets, and then gradually dies out; a diffuse light fills the sky; here and there a few luminous patches, resembling light clouds, open and close with an incredible rapidity, like a heart that is beating fast. They soon get pale in their turn, everything fades away and becomes confused, the aurora seems to be in its death-throes, the stars, which its light had obscured, shine with a renewed brightness; and the long Polar night, sombre and profound, again assumes its sway over the icy solitudes of earth and ocean."

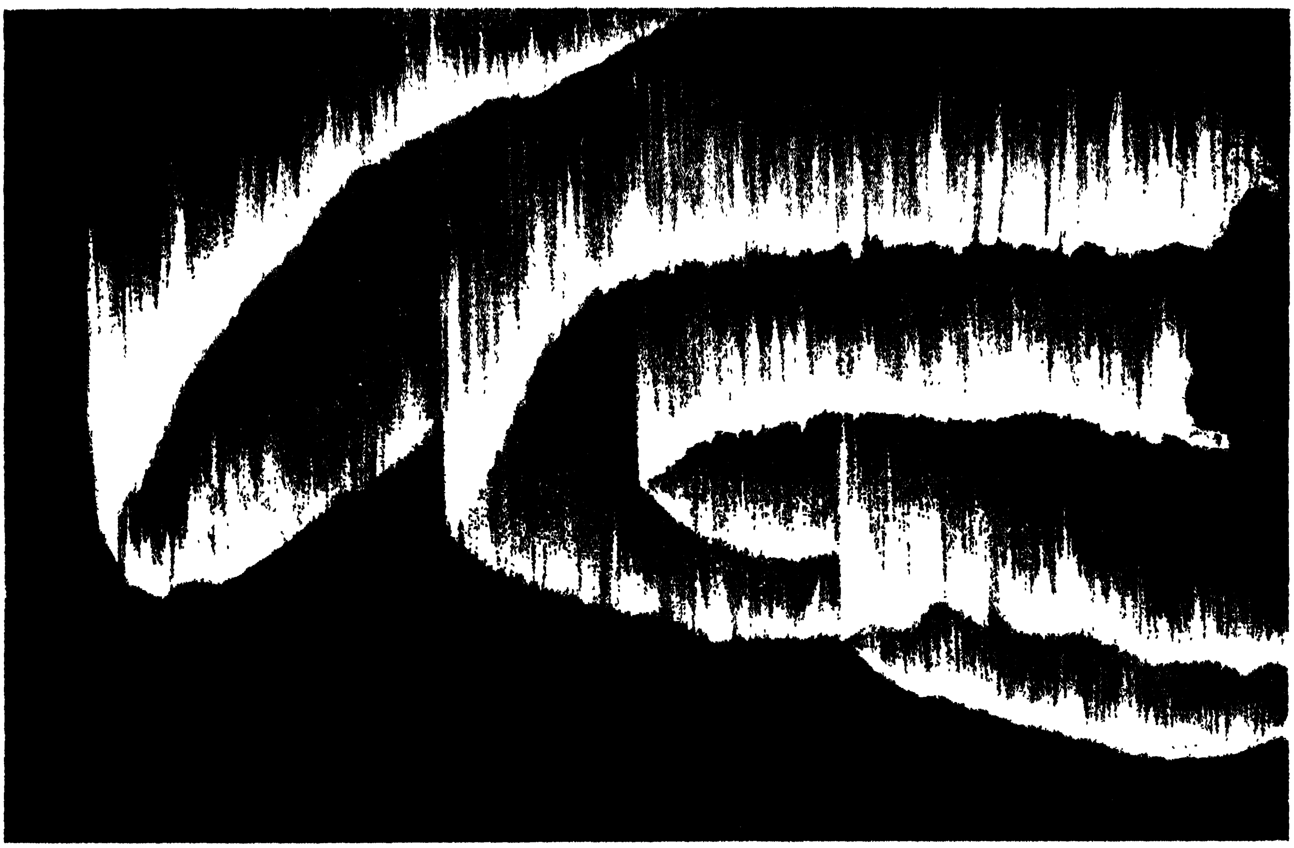


An auroral arc appearing low on the horizon in the Arctic. In colour it is sometimes pure white and at other times red. It some cases it shoots forth rays



A diagram showing, by means of wavy lines, how the variations in the Aurora Borealis, the magnetic needle, and sunspots, over a number of years, closely coincide

Although sometimes the aurora takes on one form and sometimes another, it frequently exhibits many of the forms at one time, or it may change rapidly from one appearance to another. The auroral arch which is so often seen in the Arctic regions varies in breadth from one to six diameters of the Moon. It remains visible for several hours at a time and is in a constant state of motion all the time. It rises and falls, extends towards the east and towards the west, breaks and reunites, and then shoots out rays. When the rays are very bright they sometimes assume a purple colour.



A display of the Aurora Borealis having the appearance of luminous curtains suspended from the sky. This particular display was witnessed by travellers in Spitzbergen, but it is not at all unusual for golden draperies like these to be seen floating in the Arctic sky

THE BUILDING OF THE GREAT CATHEDRAL

What would London be without its magnificent cathedral in the centre of the City and its towering dome that forms a landmark known all over the world from photographs and pictures? The story of the erection of this splendid building is a great romance, and its completion and continued existence are a tribute to the surpassing genius of one man, Sir Christopher Wren, who was not a professional architect, but a professor of Astronomy. Here is the story of the building of St. Paul's

In the dozen years or so before the Great Fire of London St. Paul's Cathedral, the heart and glory of the capital, had been so neglected as to become unsafe. Attempts at restoration had been started in Charles the First's reign, but were cut short by the Civil War, and after Charles's execution what remained of the restoration fund was diverted to the payment of Parliamentary troops instead of to the repair of the great cathedral.

As soon as Charles the Second came to the throne it was realised that if St. Paul's was to be made safe the work of repair must be taken in hand at once. Dr. Christopher Wren, who was really not a professional architect at all but a professor of astronomy at Oxford University, was called in to make a survey of the cathedral.

Rubbish at the Core

He found the fabric so insecure as to be dangerous and it is rather strange that one of the faults of the original builders was the very fault that later Wren himself was to commit, not through any carelessness of his own but through the parsimony of others. It was to give much trouble to the Dean and Chapter of our own day.

He found that the great pillars holding up the roof of the old Cathedral were not solid as they appeared to be, but had a core of rubbish which had yielded under the weight and been crushed to powder. It was this very fault which had to be set right in Wren's own cathedral during the present century. There, too, the pillars were found to be filled with rubbish and holes had to be bored in them and concrete squirted in to solidify and make the pillars strong enough once more to hold up the great dome.

Wren drew up plans for the repair of old St. Paul's, and the work was put in hand, but before much had been done the Great Fire came and burned all but the massive walls. These stood, forming a striking landmark amid the desolation which had levelled nearly all the rest of London. And they stood for years, for at first men were too busy rebuilding their homes and business premises to give much attention to the great cathedral.

Wren had been appointed principal architect for the rebuilding of the whole City of London, but although the Dean and Chapter of St. Paul's consulted him about patching up a part of the old cathedral for temporary use, they took little notice when he opposed them.

A committee was appointed to look after the patching up, but a year later the Dean had to confess "our work at the west end of St. Paul's is fallen about our ears." First one pillar fell, then another, and at last the Dean and Chapter had to beg Wren to come in and help with all possible speed. Apparently Wren did not hurry, for a few weeks later the Dean wrote to him again stating that my Lords of Canterbury, London and Oxford were agreed that "without you they can do nothing. I am, therefore, commanded to give you an invitation hither in his Grace's name and the rest of the Commissioners with all speed." Wren went to London in answer to this urgent request, and convinced the committee that patching was out of the question.

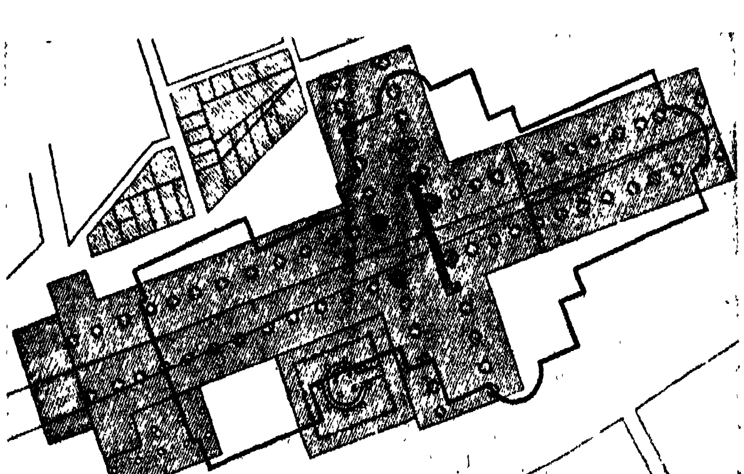
Thereupon King Charles issued a warrant for taking down the walls and clearing the ground to the foundation of the east end, so as to make room for a new choir as part of a possible new cathedral. Wren's idea was to provide a temporary meeting place by building a new choir first.

Useless Patching

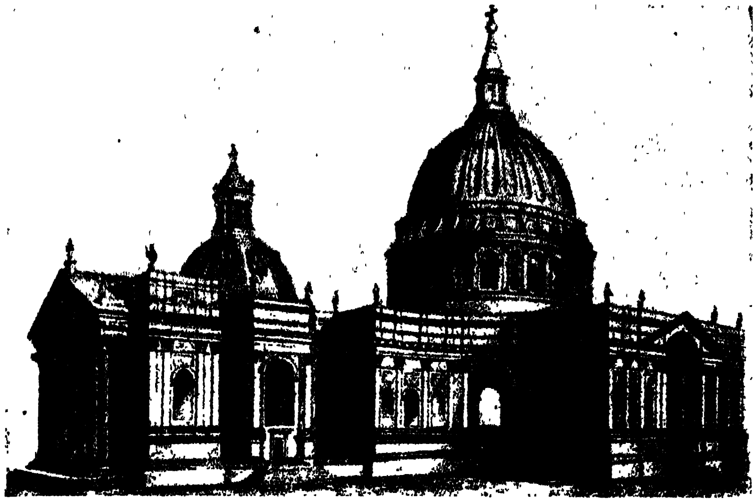
"There will be time," he said, "to consider of a more durable and noble fabric to be made in the place of the lower and eastern parts of the church, when the minds of men, now contracted to many objects of necessary charge, shall, by God's blessing, be more widened after a happy restoration both of the buildings and wealth of the City and nation."

It was still hoped to make use of what remained of the old cathedral, and some of the large and massive pillars were cased with stone to strengthen them; but it was soon found that they were quite incapable of

Old St. Paul's burning during the Great Fire of London. From an engraving made in the year of the Fire



The ground plans of old St. Paul's and the present cathedral compared. The shaded part is old St. Paul's and the outline is the present building



Sir Christopher Wren's first design for St. Paul's Cathedral

lasting repair. It was, therefore, decided to clear the whole of the foundations of the old cathedral and to put up an entirely new building.

But it was one thing to talk about clearing away the ruins and another thing to do it Some of the outer walls were so massive as for a long time to defy all attempts at demolition, and Christopher Wren decided after seven years of slow progress, to blow them up with gunpowder. We can hardly imagine attempts to blow up a large area in the centre of London to-day, but no one seems to have thought the proposal strange in the seventeenth century.

The main walls stood 80 feet high and the middle tower, which had formerly borne the tall spire, still stood 200 feet above the ground. It was to remove this tower that Wren first decided to use gunpowder. But he was very careful not to overdo the business; he used only 18 pounds of powder and fired it so successfully as to bring down not only the tower but four great arches. Then he had to leave London for a short time, and left the next operation to one of his subordinates.

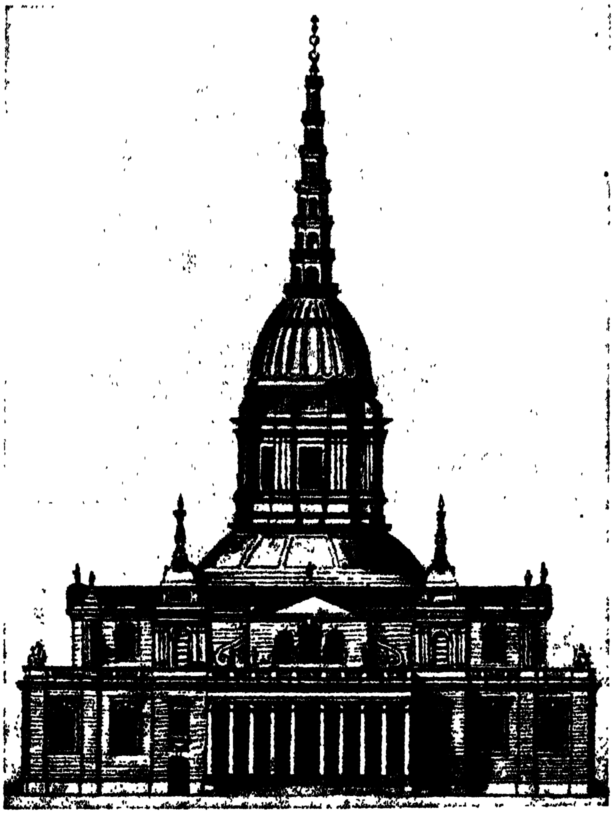
Trouble soon followed, for as Wren says, this man "too wise in his own conceit put in a greater quantity of powder and neither went low enough nor sufficiently fortified the mouth of the mine." The result was that, although he brought down part of the walls, the explosion shot a stone across the churchyard into a house where some women were sitting at work. Fortunately nobody was killed or injured, but the alarm and excitement created was so great that Wren was ordered to use no more powder.

Battering Down the Walls

It was a severe handicap, but Dr. Wren was not the man to be beaten easily. If he could not blow up the walls he would batter them down with a battering ram.

We are told that "he took a strong mast of about 40 feet long, arming the bigger end with a great spike of iron fortified with bars along the mast and ferrules. This mast in two places was hung up to one ring with strong tackle and so suspended level to a triangle prop, such as they weigh great guns with; thirty men, fifteen on a side, vibrated this machine to and again, and beat in one place against the wall the whole day; they believed it was to little purpose, not discerning any immediate effect; he bid them not despair but proceed another day; on the second day the wall was perceived to tremble at the top and in a few hours it fell."

It was a long time since a battering ram had been used in London, if it ever had been before, but it proved so effective that Wren beat down the rest of the walls with its aid, and cleared the ground sufficiently to allow of the new building being begun. The west end of the church, however, was not pulled down till twelve years later.



The last design for St. Paul's prepared by Wren and approved

Wren meanwhile had drawn up various plans for the new cathedral, one of which would have given a magnificently original building. But the great architect was interfered with by little men, ecclesiastics and others, who knew nothing about building and less about architecture. Alterations had to be made here, there and everywhere, and at last Wren grew tired and prepared an entirely new design at which he himself must have laughed.

It would almost seem that he intended this design as a joke just to see how far the wiseacres would go. It was a strange mixture of classical and Gothic architecture with a lofty spire on top of a dome. Though he knew the folly of men in power, yet probably Wren was surprised when this strange design was approved, and on May 14th, 1675, the King issued a Royal Warrant for beginning the building, declaring that among the various designs presented by the architect he had "particularly pitched on one as well because we found it more artificial (artistic), proper and useful as because it was so ordered that it might be built and finished by parts."

The Artful Architect

The design selected was the one with a spire on a dome. But Wren, though harmless as a dove, was as wise as a serpent, for he obtained from the King "liberty in the prosecution of his work to make some variations rather ornamental than essential as from time to time he should see proper." The architect availed himself of this liberty with a vengeance, for the cathedral he built bore little resemblance to the design which was approved. How he must have smiled as he made the drastic alterations which were to pass as merely "ornamental" changes!

Of course, the question of cost was an important one, and everybody was interested when Charles the Second set a fine example. He "promised £1,000 by the year to be paid quarterly out of our Privy Purse, and to be continued

during the reparation of the said church." It is true, there is no record that he ever gave a penny, but no doubt the promise encouraged others who were more men of their word than the Stuart king. Wren himself, though a poor man, gave £60. A subscription list was opened and many donors gave generously, including the bishops. Part of the cost was obtained from a tax on all coal coming into London.

The first thing Wren did was to examine the ground for the new foundations, and he dug wells in several places for the purpose. He went down through the hard earth and dry sand to a bed of sand and water, where he found shells which he imagined to be sea-shells, but which were really the remains of fresh-water creatures. He speaks of this sand as a "firm sea beach which confirmed what was before asserted, that the sea had been in ages past where St. Paul's now is." But at the north-east corner the architect made a disquieting discovery, for there was a great pit filled with pieces of broken pottery, from which in some previous age potters had dug out all the earth. His assistants suggested that he should drive piles at this place to support the new building, but Wren refused because, while timber will keep sound if immersed in water, it rots if left in a dry or a merely moist situation. Instead, he built a short arch to span the chasm and carry the north-east corner of the choir of the new cathedral

Underground Water

It might be asked why Wren did not use the old foundations. There were two reasons. Had he done so, he would have been too much confined by the old ground plan, and in the second place, owing to the widening of the streets he had to shift the position of the cathedral slightly. New foundations were, therefore, necessary.

Wren himself realised the danger which is now regarded with very great concern, of the water being drained off from the sand, and thus causing a sinkage. It is a danger that is greater than ever at the present time, when the foundations of buildings are carried much lower than used to be the case, when tube railways are excavated, and various other opportunities given for the water to escape.

That the ground was not altogether suited for the support of such a great weight as is furnished by the dome, was proved even in the eighteenth century, for the foundations began to give way and considerable repairs had to be carried out by Edward Strong, son of Wren's master mason.

At last all was ready for starting the actual building, and the great work began. The first stone was laid on June 21st, 1675, at the south-east corner of the choir, by Wren, assisted by Mr. Strong, his stonemason.

A remarkable incident occurred in the early days of the building. Sir Christopher Wren (he had been knighted in 1672) was setting out on the ground the dimensions of the great dome, and he told a workman to bring him a flat stone to mark a certain point. The man went to a rubbish heap and picked out what proved to be a fragment of a tombstone from the old cathedral. He handed it to Wren, who noticed carved on it one word from the old inscription, "Resurgam," which is the Latin for "I shall rise again." It was a startling and apt reminder, and evidently impressed all who had anything to do with the new building. When the Cathedral was finished a phœnix on its fiery nest was sculptured over the south portico with that same word "Resurgam." Never had there been a truer prophecy.

When the man brought the stone picked up at hazard Wren noticed the word "Resurgam," meaning "I shall rise again"

The work went on, year by year, although the records about it are very meagre. Twenty-two years elapsed from the laying of the first stone to the opening of the choir for Divine Service on December 2nd, 1697, which was the Thanksgiving Day for the Peace of Ryswick which acknowledged William the Third, King of England.

It was a great day for London. Three hundred thousand jubilant people flocked into the City from all parts, and the Lord Mayor, with the Corporation and all the other City dignitaries, attended in state. It was at one time intended that the King should be present, but it was felt that he would not be able to reach the cathedral through the immense crowds.

The new organ pealed out its glorious tones, and Henry Compton, the aged Bishop of London, preached a thanksgiving sermon from the text, "I was glad when they said unto me, Let us go into the House of the Lord." Since that day services have gone on regularly in the great cathedral, one of the most magnificent sanctuaries in all Christendom

A Great Work Finished

The work of completing the cathedral continued and in 1710, when Sir Christopher Wren was 78, his son laid the highest stone of the lantern on top of the dome in the presence of his father, who probably remained below. One account, however, states that the aged architect was himself present on the dizzy height and looked down, rather than up, as the stone was laid. We know that during the whole of the building Wren used to be drawn up in a basket several times a week to see how the men were getting on, and it is quite possible that he may have mounted to the top of the dome to see the crowning of his great work.

But whether he watched the ceremony from below or from above, he must have been a proud man. Never before had such a vast church been built under the eye of its original architect. All the great cathedrals of the Middle Ages had had a succession of architects, for they were built during many generations. Here was one of the greatest churches in Christendom designed and built under the direction of the one man who alone in that age could have projected such a magnificent fane.

And how did the ecclesiastics and the public who were to benefit by his great

work honour and reward the architect who had given the best years of his life to the task and produced such a wonderful monument? His remuneration during all the long years that he was superintending the work was little more than that of a workman. He was paid £200 a year—less than £4 a week—and even part of this was held back for a time by a spiteful committee who pretended that Wren was not getting on fast enough with the building, when all the time it was their own miserable and unwarrantable bickerings and jealousy that delayed the work.

These arrogant men, ignorant of the very elements of architecture, insisted on a high railing being put round the cathedral, which hid its beauties from the people in the streets, and they even had the temerity to compel Wren to change his architecture and build a balustrade round the top of the building, though the architect protested strongly at the outrage.

"I take leave," he said, "to declare I never designed a balustrade Persons of little skill in architecture did expect, I believe, to see something they had been used to in Gothic structures, and ladies think nothing well without edging on. I should gladly have complied with the vulgar taste, but I suspended for the reasons following."

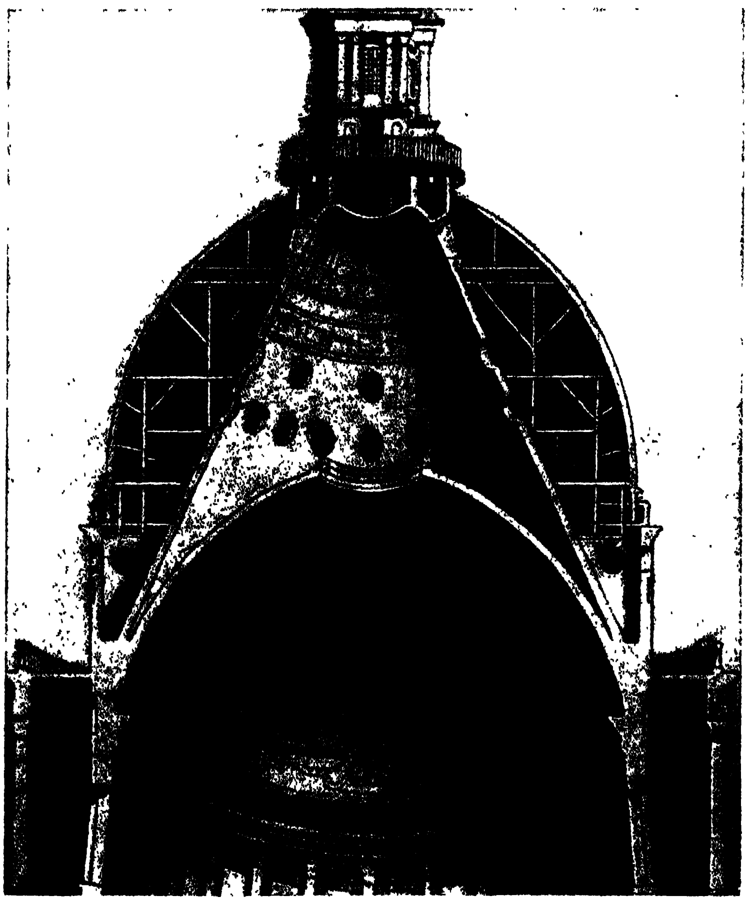
Broken Harmony

He then goes on to point out that there was already over the entablature a proper plinth which regularly terminated the building, and that anything like a balustrade would break into the harmony of the whole structure and be contrary to the principles of architecture.

But the Commissioners were to get their revenge. They insisted on the balustrade and in the following year, when Wren was 86 years old and had held his office for 49 years, they dismissed him from his post and appointed an incompetent ignoramus to succeed him. This man, William Benson, had to be dismissed in the following year for incapacity, yet he was given another lucrative post while poor Wren had to live in obscurity. His only consolation was in the satisfaction of a great work accomplished and in periodical visits to see the monument his genius and industry had raised

"In the beginning and completion of St. Paul's by Wren," wrote Horace Walpole, "are a fabric and an event which we cannot wonder left such an impression of content on the mind of the good old man that being carried to see it once a year it seemed to recall a memory which was almost deadened to every other use." There at intervals under the great dome, sat the aged architect of nearly 90, looking up at his marvellous work.

Another genius to whom the great cathedral owes much was Grinling Gibbons, the greatest wood-carver of all time, whom John Evelyn, the diarist, had discovered in a thatched house near his home at Sayes Court, carving a Crucifixion. Evelyn introduced "the incomparable young man," as he called him, to the King and to Sir Christopher Wren, and from that time his fortune was made. His work is to be seen in many places, but the greatest of it is in St. Paul's Cathedral. We may see it in the choir. As Walpole says, "There is no instance of a man before Gibbons who gave to wood the loose and airy lightness of flowers, and chained together the various productions of the elements with a fine disorder natural to each species."



A sectional drawing of Wren's great dome showing how the stone lantern with its ball and cross are supported not on the dome, but on a conical wall built between the outer and inner domes

St. Paul's was completed, except for the ball and cross which were put on later, though curiously there is no record of the exact date. The ones we see to-day are not the original ball and cross, for these were erected as late as 1821, and it is interesting to know that in 1848 a "crow's nest" was erected on the top of the cross by the Government Ordnance Surveyors as the best place from which a survey of London could be made.

Wren had wanted to decorate the inside of the dome with mosaics, but the Committee would not agree to this. That adornment, however, has been carried out in recent years.

The total cost of the cathedral was £747,661 10s., an amazingly small sum for such a vast and beautiful building.

A Miracle Performed

Wren performed a miracle, for throughout the building he was handicapped for want of adequate material and had to use what he could lay his hands upon. The bulk of the stone, however, was from Portland, specially hewn and brought to London for the purpose.

It has been well said that Wren hung his dome in air.

It may be asked why Wren, who was by profession an astronomer, ever came to be invited to act as an architect. Well, it must be remembered that Wren was one of the most remarkable Englishmen that ever lived. He was not only an astronomer, but he was an artist, a naturalist, an inventor, a mathematician, a student of anatomy and medicine, a theologian, a meteorologist, and an architect. His father, who was a clergyman, had designed a new roof for his parish church at East Knoyle, and no doubt Wren learnt something of the principles of architecture from this parent.

The first we hear of his work as a professional architect is when he was invited in 1661 by Charles the Second to act as surveyor-general to His Majesty's Works, though nominally as an assistant to another official.

The architect's tomb in St. Paul's is very modest, and is to be seen in the crypt of the cathedral. At the entrance to the choir is an inscription in Latin, "Si monumentum requiris, circumspice," which means, "If you seek his monument look around."

WHAT THE MONSOON MEANS TO INDIA

We often read in the newspaper that the monsoon is approaching India, or has broken over the country. What does this mean? The reference is to a south-westerly wind that brings moisture to India and gives the vast peninsula the rain without which its millions of inhabitants would perish. Monsoon winds also blow in other parts of the world, as, for example, over Spain and Portugal, and they are not always wet, as we read in this account of the Indian monsoons

The prosperity and welfare of the whole of India depend more than anything else on the south-west monsoons, winds which blow over the country during the summer and bring the life-giving rain. Of course, in some areas the British have made the country partially independent of the monsoons by organising great irrigation schemes, but monsoons and prosperity to all intents and purposes mean the same thing to India. If the south west monsoon fails to bring the rain at the proper season terrible disaster stares tens of millions of people in the face.

The word "monsoon" simply means "season," and it has been given to the winds of India because they blow from certain directions at certain seasons of the year. In the winter, north-east monsoons blow across the country and as these winds do not pass over water but come across Southern Siberia and over the Himalaya Mountains, they are dry, and are spoken of as the dry or winter monsoons.

Though, as a whole, the air currents at this season come from the north-east, they are in many parts diverted from their normal course by the great mountain chains, and in the valley of the Ganges their direction is from the north-west.

In summer, however, when the Sun travels north, the rocky highlands are quickly heated and the winds rush up from the south. This begins at the end of April, and by the middle of June the south-west or summer monsoon is blowing in full force. These winds, being warm, collect a great amount of moisture from the Indian Ocean as they pass over it, and then they give this up in the form of rain as they pass over the Indian peninsula.

It is the south-west monsoons that give India the greater part of the rain it receives. The moist winds when they strike the Western Ghats cause an abundant rainfall over the western coastal plain, which lasts almost continuously through May, June and July. Then over the eastern half of the peninsula the rainfall is only slight, but it increases again when the still moist winds reach the Deccan. On they pass, over the hot plains, giving up none of their moisture, but the rain falls again when the winds strike the north western Himalayas.

The south-west monsoon also gives heavy rains to the south and west of Ceylon, and after passing over the Bay of Bengal waters nearly the whole of Burma.

This photograph shows the approach of the south-west monsoon over the River Hooghly on which the city of Calcutta is situated. The Indian people watch anxiously for its coming and when the dark clouds are seen, as here, great is their joy

NIAGARA IN ITS GLISTENING WINTER DRESS

Niagara is a magnificent sight in winter, when Jack Frost has decked the country round in a garment of sparkling white. The spray from the Falls covers everything and becomes frozen, and the beauty of the Falls, when set in the glistening framework, needs to be seen to be realised. Of course, the Falls themselves never freeze, but once when there was an ice-jam in the upper river, the water was almost entirely cut off and the mighty Falls became for one day only a mere trickle. This was on March 29th, 1848

RAIN FALLING OVER THE DRY DESERT

There are parts of the Sahara where the ground is perfectly dry, and is never moistened by rain from one year's end to another. Yet even in these parts from time to time clouds are seen in the sky, blown across by the winds from the sea, and these clouds, reaching cold layers of air above, yield up their moisture, which falls as rain. But where does the rain go, seeing it never reaches the parched, sandy ground below? Well, as it falls from the colder regions above it reaches layers of air made hot by radiation from the sun-warmed ground, and here the rain evaporates while falling, changing back into invisible water vapour

WHY THE SNOW WRECKS THE TELEGRAPH WIRES

It seems wonderful that a substance as light as snow can, when it settles on objects as slight as telegraph and telephone wires, bring these down with a crash. Many people cannot understand the mystery, but it is really quite simple when we know the facts, which are set out on this page

When there is a really severe snow-storm with a hard frost and a strong wind, the telegraph wires all over the country meet with disaster. The snow settles on the wires, and as these are blown to and fro by the fierce wind they sway and either snap their poles or tear them out of the ground. In a storm that occurred in February, 1933, for example—the fiercest blizzard that Britain had experienced for half a century—hundreds of miles of telegraph and telephone wires were wrecked in this way.

What is it that gives the snow its great power to do so much harm? Well, it must be remembered that although single flakes of snow are very light, when they are accumulated in masses and pressed together with the weight of additional flakes on top, they form an appreciable load.

Take, for instance, a tree. We know that in terrific snow-storms trees sometimes have their boughs broken off by the weight of snow. It has been estimated that a tree fifty feet high and with a circumference, including all its branches, of just over sixty feet, after a heavy snow-storm carries a burden of as much as five tons of snow.

Of course, if there is not a hard frost the snow soon gets blown from the tree or other place on which it has been deposited. But when there is a hard frost the snow is frozen into ice, and a cubic foot of ice weighs 57½ pounds; that is, two cubic feet, which is not a very great volume, weighs over a hundredweight.

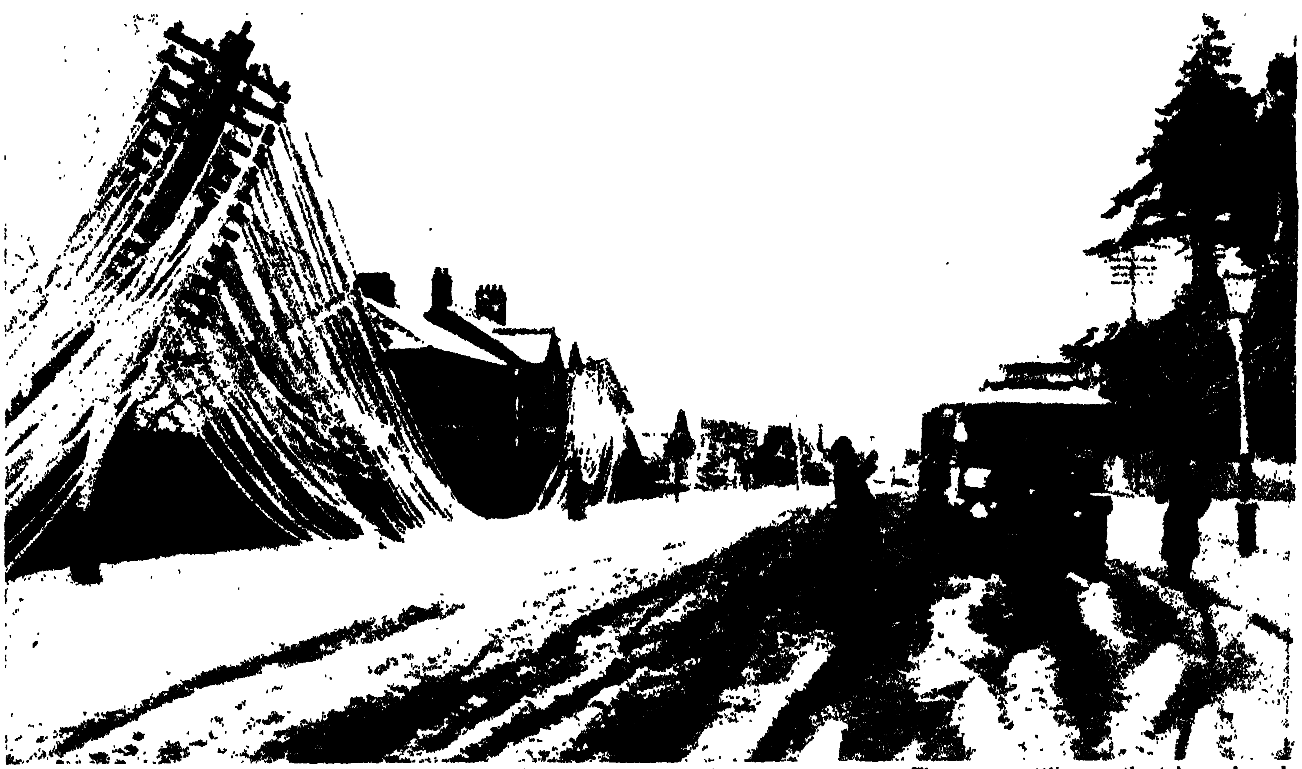
We can understand, therefore, that when there is an accumulation of frozen snow on a numerous collection of telegraph wires, the weight is very great. In one blizzard, for example, the weight of frozen snow on a run of eighty telephone wires was four tons for each span between the poles. The strain upon the wires, therefore, when a fierce wind was blowing and hurling these four tons together with the wires to and fro, must have been terrific. No wonder that the strain snapped off the poles or tore them from the ground by the hundred.

A telegraph pole is, of course, fairly stout and strong, and without a wind it could resist the pull of the weight upon the wires. But the wind adds enormously to the strain and disaster follows.

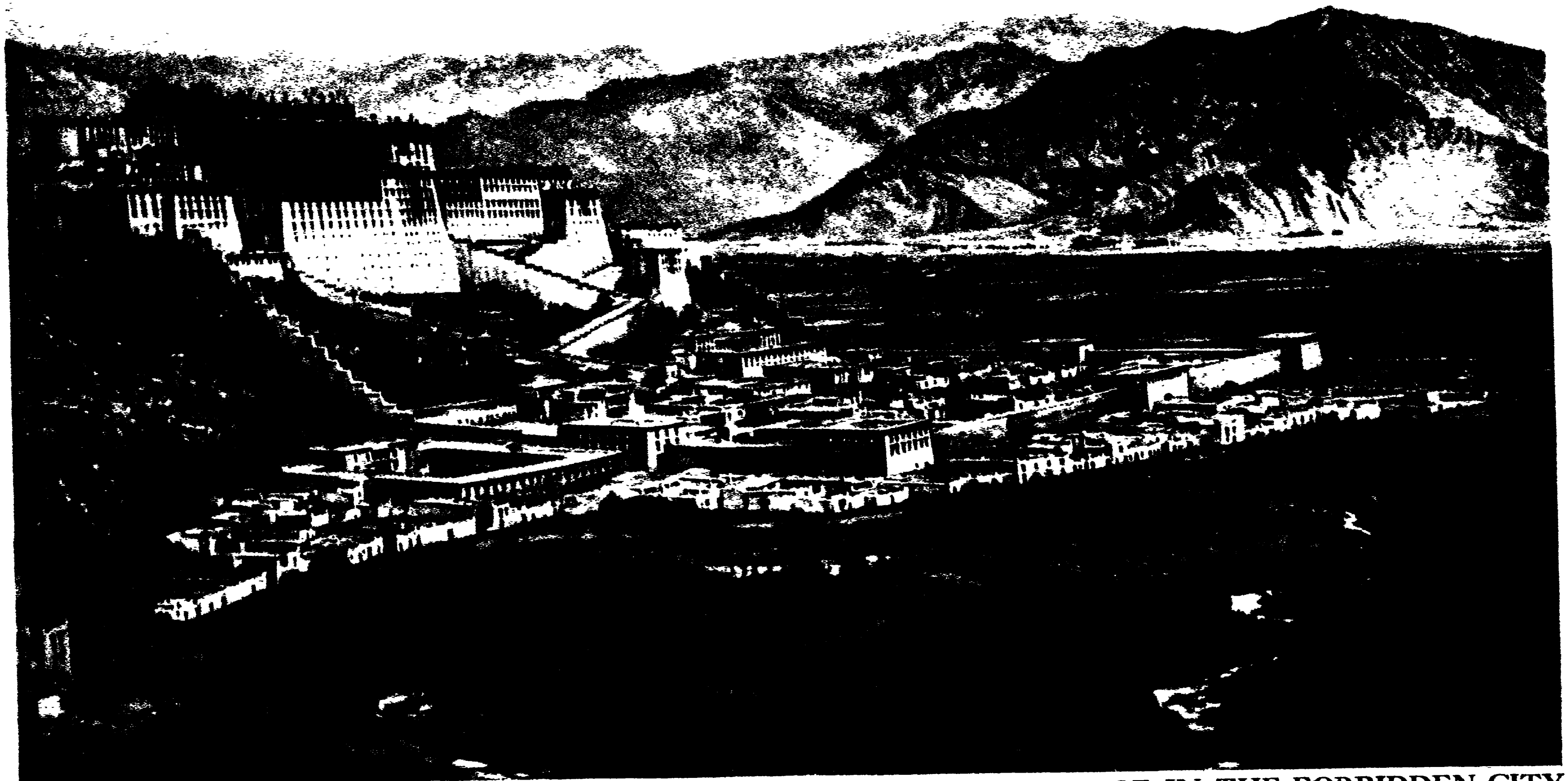
It must be remembered that even without the accumulation of snow on the wires the wind, when it is really fierce, can play havoc with telegraph and telephone wires. Just before the Great War a terrific rain and wind storm swept across England, and thousands of miles of telegraph and telephone wires with the poles that supported them were thrown to the ground. It took some years to get everything right afterwards. This was without the snow on the wires. When this additional strain is added it is a marvel that more damage is not done than actually is.

In America worse storms are experienced than ever come to England. During a storm in December, 1924, which began a week before Christmas, and swept along a belt 150 miles wide, from Texas to the Great Lakes, in three States alone the frozen snow tore down 34,000 poles and put more than 25,000 miles of telephone wires out of use.

During a fierce snow-storm in December, 1929, the masses of snow caused a breakdown of the distribution of electric power from Niagara Falls. Fifteen great towers belonging to one company alone collapsed, and all the power lines from the Falls to the city of Buffalo, except one, were wrecked. Even this could not be used until a heating current had been sent through the wires to melt the heavy coating of ice that surrounded them. Hundreds of trees were blown across the roads, and this made it exceedingly difficult for the repairing staffs to begin making good the damage.



A photograph of the main road through a village in Wales taken after a heavy snow storm. The snow, settling on the telegraph and telephone wires and freezing, has loaded them with such a weight that it has brought them down with a crash.



GOLDEN ROOFS AND CRIMSON WALLS OF THE DALAI LAMA'S PALACE IN THE FORBIDDEN CITY

Lhasa, the capital of the Himalayan mountain state of Tibet and a holy city for nine million worshippers, is a small and squalid town. But over it stands one of the world's most impressive buildings, the Potala or palace of the Dalai Lama, priest-king of this remote country. From a base of some 900 feet of dead wall, the building rises by tiers of countless little windows to 300 feet, so much a part of the cliff on which it stands that it is hard to tell where Nature's handiwork ends and the builders' begins

To face page 817

NOISY WORK THAT CANNOT BE HEARD

Once upon a time we were told that a noisy noise annoys an oyster most; but recent experiments with noises have proved that although a noisy noise can be annoying, to humans as well as to oysters, it is the noises we cannot hear that are important. Indeed, some of these silent noises can destroy living things.

There are certain noises which have such a high pitch that they cannot be heard by the human ear. Scientists call this curiosity ultrasonics and define it as a zone of vibrations which are so intense that they cannot be detected by the human ear.

Sound travels in waves and at a normal pitch batters us on the eardrums to a degree of intensity governed by the length of the wave; long waves are heard as a whisper, but as the waves shorten they strike the ear drum more frequently, so explaining why a particularly loud noise, which is made up of a series of short and frequent waves, has serious effect upon the nerves. Should the sound vibrations become excessively rapid, they get beyond the range of hearing, and may mount up sufficiently to destroy the eardrum.

Radio waves furnish a good parallel. When we tune in to a broadcast the long ether waves have no effect upon our bodies, but if we get in the path of the much shorter wavelengths of X-rays, which are just the same kind of waves, we would soon find ourselves suffering serious consequences.

Human and animal ears do not always hear the same kind of noise. Dogs, for example, can hear noises which we cannot detect, and you can buy special dog whistles which when blown give a note that can be heard by the dog but not by his master.

Professor Games, of Texas University, U.S.A., was the first scientist seriously to study these curious silent noises. His apparatus consisted of a nickel tube 12 inches long and three-quarters of an inch in diameter placed between the arms of an electromagnet. When an electrical pressure of several thousands of volts was applied to the magnet the nickel tube vibrated, and when the tube was tapped sharply it gave out a note like that of a tuning fork.

When such a tube is sounded or vibrated in the air, its vibration is so intense that the tube splits in the centre, so to stop this the lower part of the tube is kept dipped into a tank of water, which damps down the vibrations. The noise of the vibrations cannot be heard by the human ear, but they can be detected by special electrical listening instruments.

Professor Gams found that when the tube was vibrated or sounded in water a small fountain was thrown up. This proved that the "silent" sound waves from the tube were of such a high pitch or intensity that the water was being hammered. The hammering of the water was then reflected back against the tube. Microscopic examination showed tiny scratches where the pounding of the water had damaged the tube.

The next step was to design an electrical generator for producing ultrasonic vibrations, and much of the pioneer work in the design and operation of these machines has been carried out in Britain by Mullard Electronics, who supplied the illustrations on this page.

This photograph shows how the vibrations of "silent" sound cause water in a tank to rise like a fountain. The drum on the left, which is connected to an electric generator, produces the sound vibrations

If some blood corpuscles are placed within the "sound" range of a tube connected to an ultrasonic generator, all the cells will be broken up in ten minutes. A frog held near the tube will be killed in five minutes. If you held your finger in the path of the sound it would become numb.

It then occurred to scientists that if ultrasonic noise could break up blood corpuscles, silent sound might be used to kill bacteria in milk and other liquids.

Milk fresh from the cow contains bacteria, but provided the cow is healthy and the milk is consumed soon after it has been obtained, the bacteria has little ill-effect. But should some time elapse between milking and consumption the temperature of the milk will rise sufficiently to increase the number of bacteria to several hundred thousand per drop.

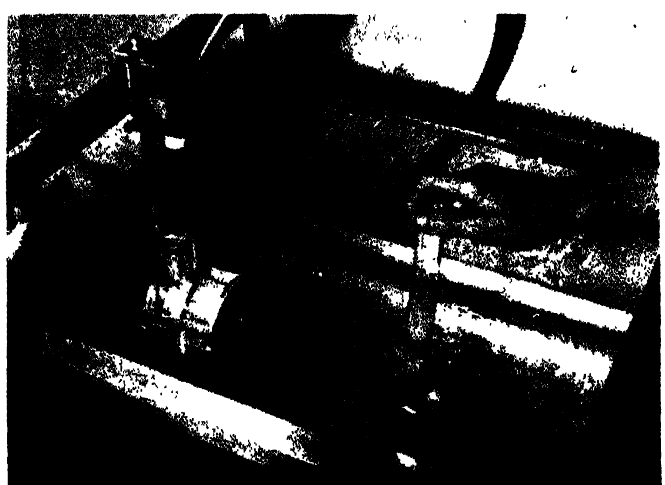
To prevent this, milk for commercial distribution is pasteurised, that is, it is heated in vats until the bacteria are made harmless.

When bacteria-laden milk is flowed past a tube giving out ultrasonic vibrations the bacteria are destroyed because the vibrations force the bacteria first in one direction then in another with such force that they are torn to pieces.

Purifying milk by sound has two great advantages over pasteurisation. Heating milk, the pasteurisation method, does not kill all the bacteria, a proportion of which merely become inactive and revive when the milk cools. Moreover, the high temperature is liable to spoil the vitamin contents of the milk. On the other hand, noise treatment effectively kills all the bacteria and as no reheating is used none of the food value of the milk is lost.

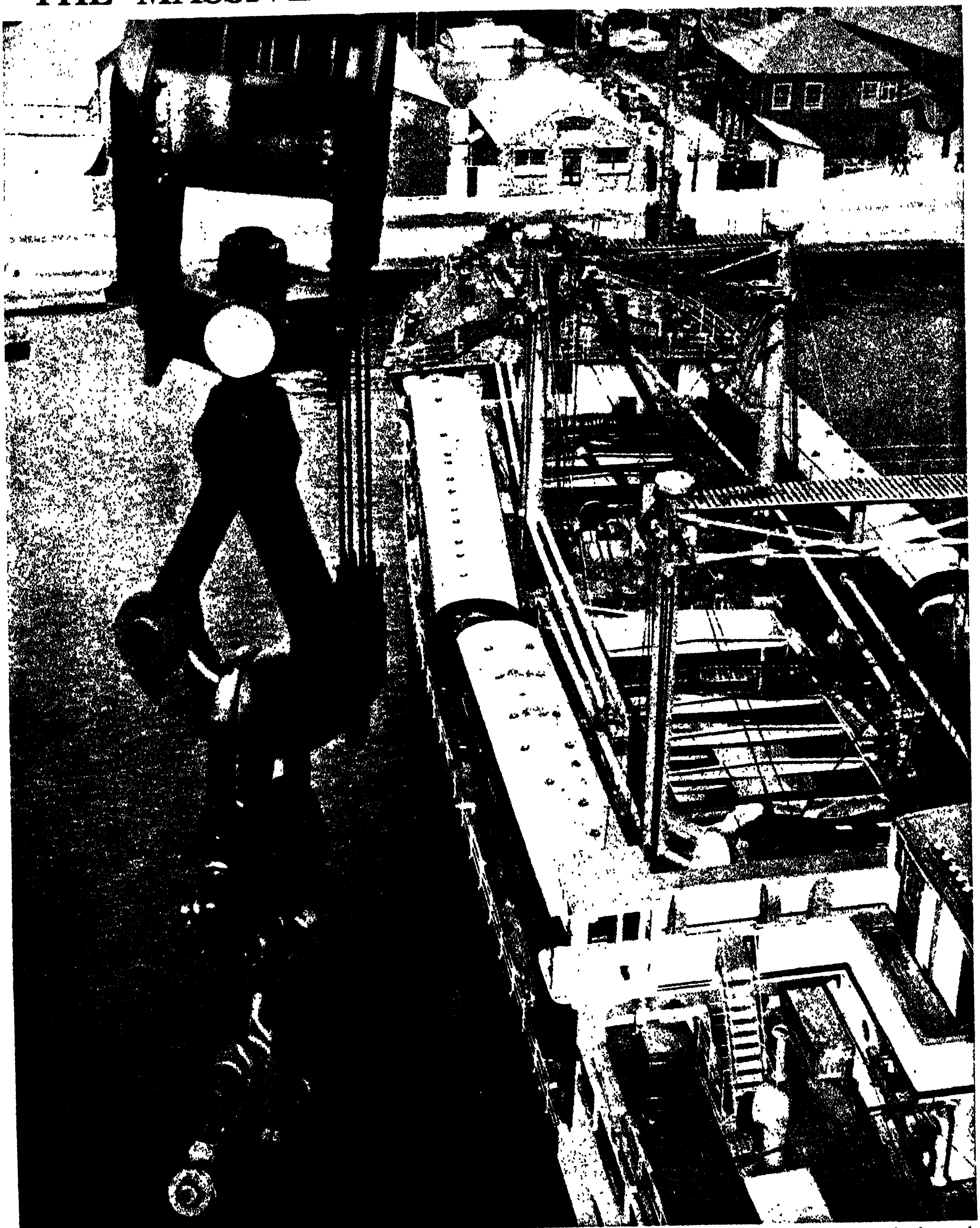
Killing bacteria by noise is still in the experimental stage, but some day our milk may be purified by silent sound.

Ultrasonics has been used successfully for removing dirt. The article to be cleaned, whether textile, glass, metal or plastic, is placed in water and the vibrations literally shake off the dirt. Silent sound will also join metals by battering them together.



When the metal rod being held in this tank of water is removed, it will be found to have been pitted by the sound vibrations from the generator. The sound vibrations are strong enough to kill frogs

THE MASSIVE LINKS THAT LIFT 100 TONS



Here we see the hook and shackles of a huge electric crane lifting on to a ship the carriages of an express train. The crane also lowered on board the train's locomotive which weighed over 100 tons. Most people who saw the operation were greatly impressed by the lifting-power of the crane, and few realized that even that powerful machine would have been useless if there had been the slightest flaw in the hook ; for a crane can lift only what its hook will bear.

THE IMPORTANCE OF THE BIG HOOK

When a powerful crane has been made with its wonderful mechanism for lifting enormous weights, everything depends for its success upon the strength of the hook and chain that lift the weight. These, as we read below, must be of the greatest strength and of flawless metal, otherwise there will be disaster. The hook at the end of the chain which supports the weight is constantly subjected to enormous strains

HAVE you ever realised when looking at a great crane at work drawing up a locomotive or other heavy load, that the whole crane would be rendered useless if the chain or the hook supporting the load broke?

The links and hooks that hold up the enormous weights are really in themselves marvellous pieces of machinery. The ordinary person gives little thought to them, but the designer of a hook realises the enormous responsibility that rests upon him, and designs the hook with as much skill and care as if he were designing the crane itself.

The strength of the hook at the end of the chain depends upon two things. First of all it must be designed correctly so that the strain when it is supporting a great weight falls in the right place, and no part of the hook is strained out of proportion. At the same time it is absolutely essential that the hook should be made of the very finest steel, without a single flaw.

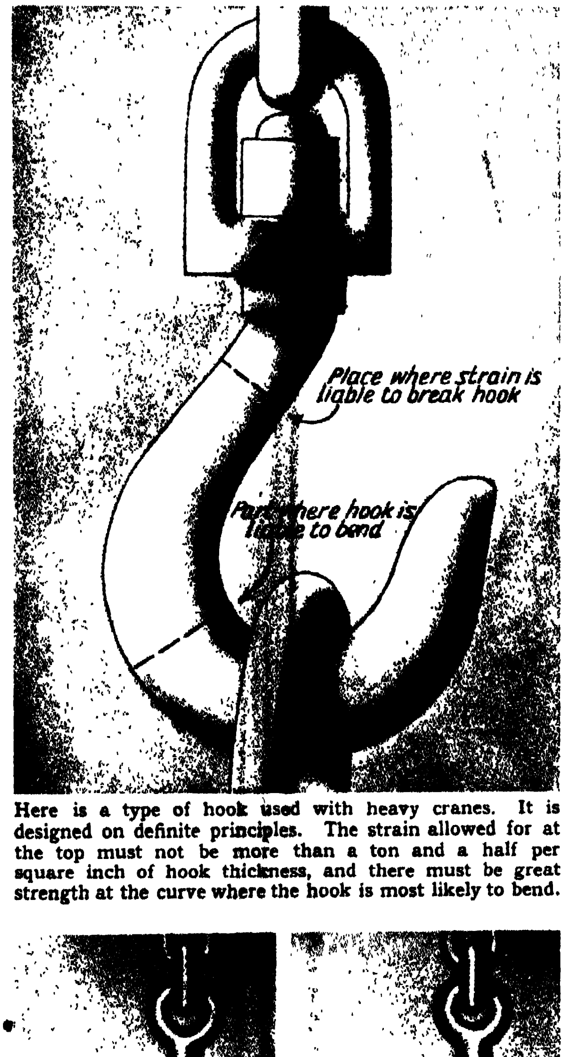
The Unseen Flaw

An unseen flaw in the middle of the metal might result in a terrible accident, for as one weak link in a chain is likely to cause a fracture and render the chain useless, so one weak spot in the metal may render an otherwise powerful hook weak and extremely dangerous.

These giant hooks are, of course, made of steel, and the steel is of a very special kind, usually tough and with the power of resisting great pulling and breaking strains.

Steel has been made for centuries, but it is only in recent times that these particularly tough steels have been produced. If it were not for the invention of these improved forms of steel it would be impossible to lift the weights that are now raised by means of cranes.

Steel is a term that is very difficult to define. It is a mixture of iron and carbon, but so also is wrought iron. Everything depends upon the proportion of carbon to iron, and this varies in different kinds of steel.



Here is a type of hook used with heavy cranes. It is designed on definite principles. The strain allowed for at the top must not be more than a ton and a half per square inch of hook thickness, and there must be great strength at the curve where the hook is most likely to bend.

Here is what is known as a releasing hook. When it is desired to release the load the hook is supporting, the rope seen in the first picture is pulled and the load is thrown off

Pure iron is a product that is exceedingly difficult to obtain, and is produced only in the laboratory. When iron ore is melted in the blast furnace the metal is drawn off and is known as cast iron, or pig iron. This contains from 3 to 5 per cent. of carbon, besides a small percentage of other substances, like silicon, manganese, phosphorus and sulphur. The percentage of iron is generally from 92 to 94. Iron of this kind is very hard, but also very brittle.

Wrought iron is manufactured by heating pig iron in a puddle-furnace lined with hematite or magnetite, which furnishes oxygen to burn out the carbon, silicon, manganese, phosphorus and sulphur in the pig iron. The oxygen of the air also helps in the process. The result is an iron which contains only ·1 to ·2 per cent. of carbon. It is very tough and malleable and has great tensile strength.

Soft and Hard Steel

Steel also is made from pig iron by one of two processes, the Bessemer process or the Open-Hearth process. In steel, curiously enough, there is anything up to 2 per cent. of carbon with minute quantities of silicon, phosphorus and sulphur. The less carbon there is the softer is the steel.

When the percentage of carbon is increased the steel becomes harder and less ductile, but its strength increases until it reaches just over 1 per cent., when the strength decreases.

Steel of all kinds is less brittle than cast iron, and of greater tensile strength than wrought iron. "Tensile" simply means that it can be stretched without breaking.

Nowadays steel is made much tougher and stronger by the addition of small quantities of such metals as chromium, nickel, tungsten, molybdenum and vanadium. By adding ·6 per cent. of vanadium the tensile strength of steel is raised from 30 tons to 85 tons per square inch. The making of these strong steels of various kinds is a complete science in itself.

EXPERIMENTS THAT ILLUSTRATE COHESION

The reason that things do not fall apart is that the particles of which they are formed are held together by a force called cohesion. We read about this force on pages 117 to 119. Here are a number of simple experiments which we can all perform and which are illustrations of this force.

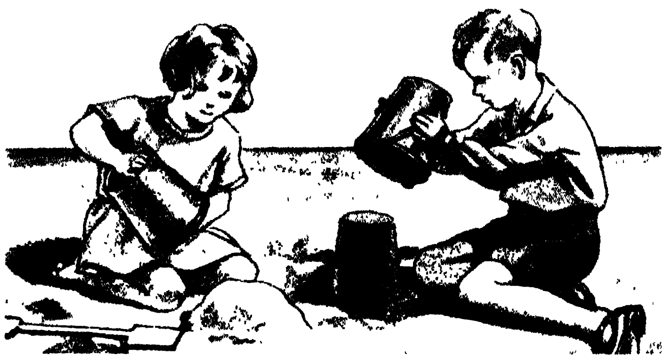
Every boy or girl who makes a sand pie on the beach knows that if the sand is dry the pie will not stand up, but as soon as it is turned out of the pail the grains of sand all fall together in a heap. If, however, the sand is moist, then a clean, neat pie can be turned out of the pail, and the more moist the sand is, as, for example, when the tide has only recently gone out, the better will the sand grains hold together.

Cohesive Force of Water

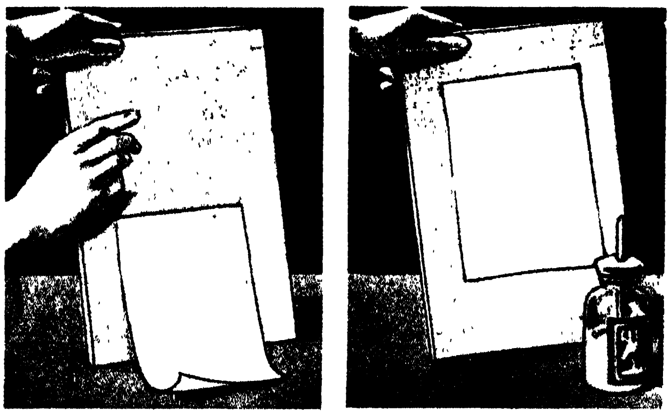
The explanation of the matter is that there is more cohesion between the particles of water than there is between the particles of sand, and so when the sand grains are covered with moisture they hold together because of the cohesive force of the water.

Here is a very simple experiment which shows why the wallpaper hangs on the wall. Take a board and place a sheet of paper on it. Now hold the board up perpendicularly, and the paper will slip off. But if a few dabs of paste or gum be put on the paper and it then be placed on the board, it will adhere and not slip off.

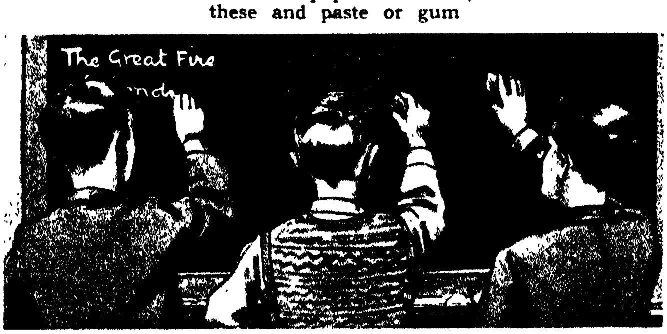
Here again there is practically no cohesion between the particles of the wood and the particles of the paper. But when the moist paste or gum is placed between the two substances this is found to have great cohesion, not only with the wood, but with the paper also. How the cohesion between different substances varies can be easily proved by trying to write on a blackboard with different materials. First we take a piece of chalk, and as we write the particles of chalk adhere to the board and the writing is plain and clear.



In making a sand pie use damp sand as the water helps cohesion



There is no cohesion between paper and wood, but much between these and paste or gum



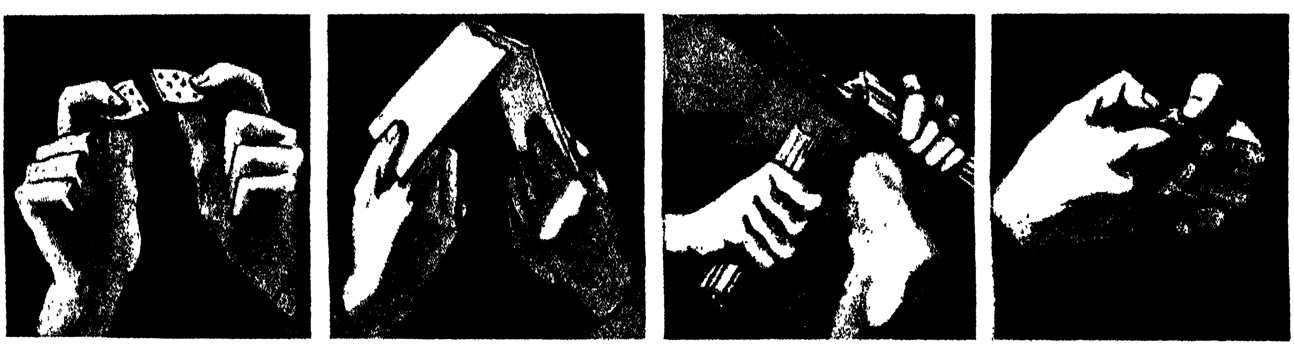
It is cohesion that makes the chalk adhere to the blackboard. There is less cohesion with shale and none with flint or granite

Now, instead of chalk let us use a piece of shale. What is the result? There is far less cohesion between the particles of shale and the board, and so, while we can see the writing, it is not so bold and clear. Now let us use a piece of stone, such as flint or granite. There is no cohesion at all between the particles of stone and the board, and the result is that no writing can be seen.

A Biscuit and a Penny

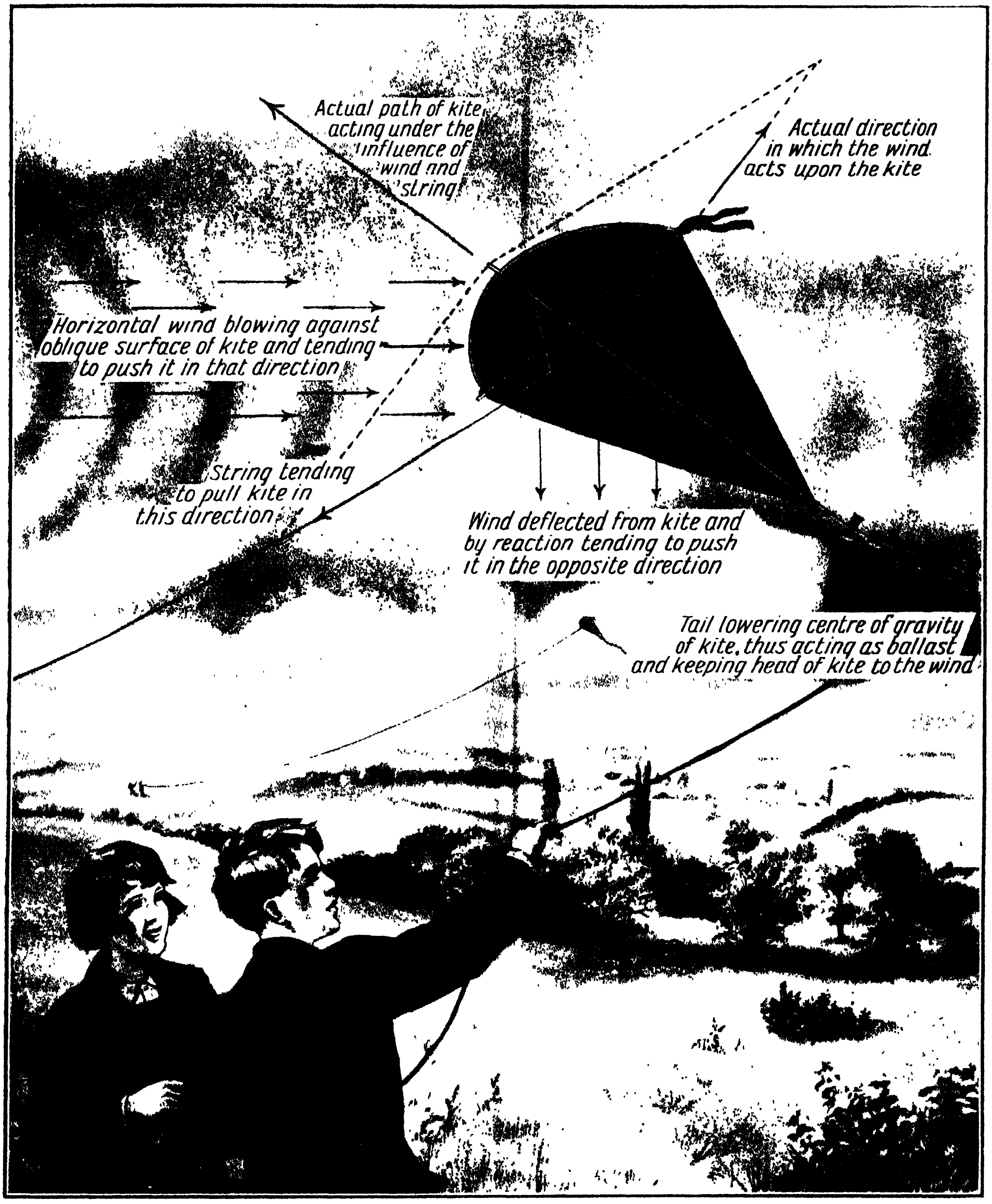
The reason some substances are so much easier to break than others is because the cohesion between the particles is less strong. Let us have an object lesson in this, by taking a biscuit, a piece of strawboard, that is, brown cardboard, a piece of wood, and a penny.

The slightest pressure on the two ends will break the biscuit. Here the cohesion requires very little force to overcome it. If we try to break the strawboard in the same way we find that this is easy to do, although considerably more force is needed than to break the biscuit. With wood the cohesion of the particles is much stronger and it is not easy to break the wood without using great force and leverage. When we come to the penny, the cohesion of the particles is so strong that our hands are not powerful enough to break it. It would require a very great force indeed to do this.



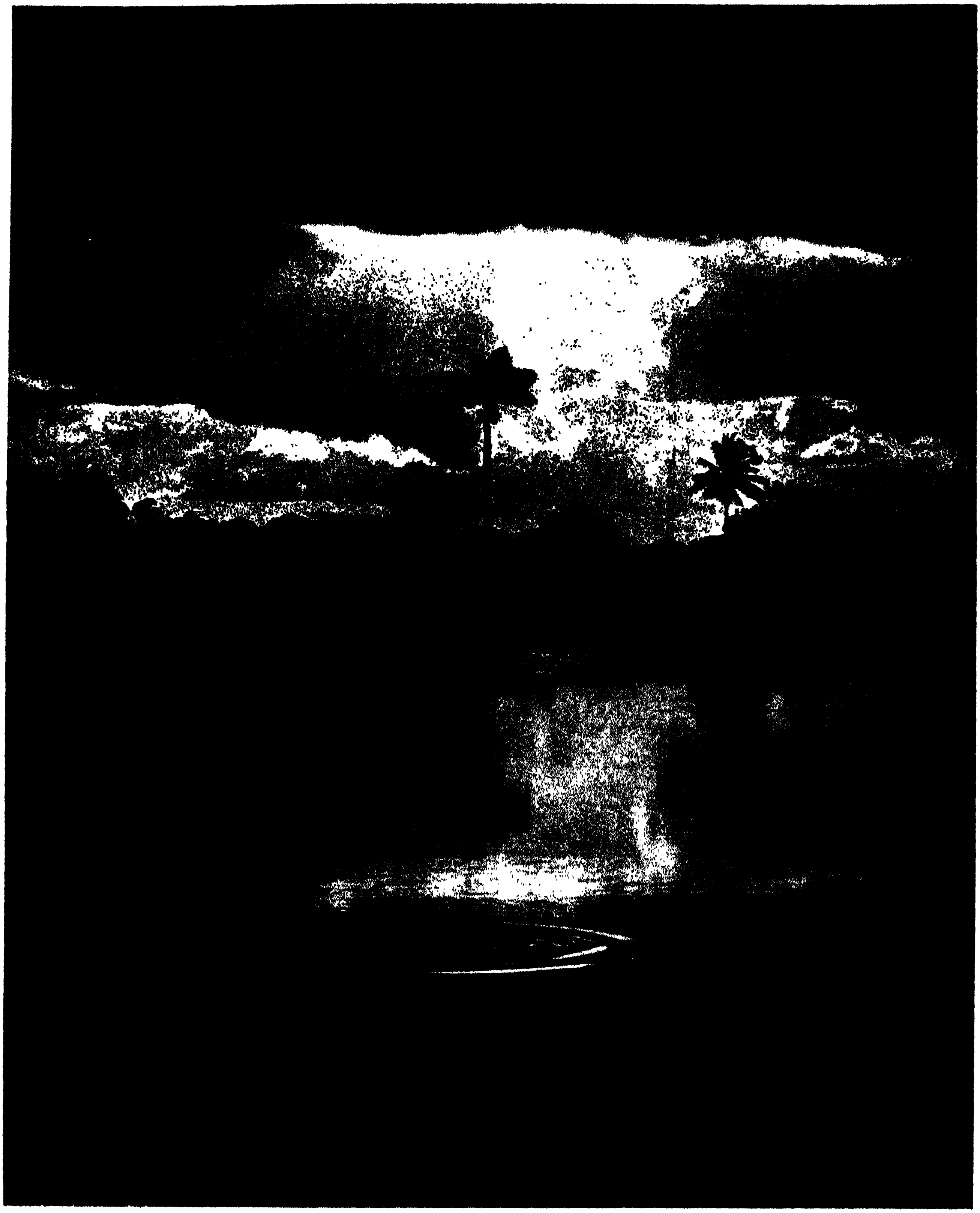
It is interesting to test the different degrees of cohesion between the particles of various substances. A biscuit will break easily, as in the first picture, and cardboard less easily, as in the second. It takes much force to overcome the cohesion in wood, and our fingers are not strong enough to overcome the cohesion in the metal of a penny

WHY A KITE GOES UP INTO THE AIR



It may seem very wonderful that a kite can be flown high up in the air, but the reason it goes up and stays up is explained in this picture. The kite is held up by one person while another runs with the string. As he does so the wind blows horizontally against the slanting face of the kite. It is deflected from the kite's face at an angle in the same way as a rubber ball is deflected if we throw it slantingly at an upright wall. As the wind comes off the kite it gives the kite a push in the opposite direction, and this is called reaction. Now the kite does not go in the direction in which the wind is blowing, that is horizontally, nor does it go up in the direction of the reaction. It takes a middle course, as indicated by the arrow in the top right-hand part of the picture. The wind, however, is not the only force acting on the kite. The string is pulling it downward in a slanting direction. The kite can go, therefore, neither in the direction of the string nor in the direction the wind is pushing it, but in between the two. This actual direction we get by forming a parallelogram on the line of string and the line representing the direction of the wind's action. The actual path of the kite is the result of the two forces of the string's pull and the wind's action

THE BEAUTY OF THE SILHOUETTE PHOTOGRAPH



There is great beauty in what is known as a silhouette photograph, that is a photograph in which various objects such as trees, buildings, hedges and people stand out black or very dark against a light background. Here is a striking example in landscape photography. Such a picture is an illustration of what may be described as the relativity of light. Light, like size and motion, is only relative. A lamp or gas flame may be very bright compared with a candle flame, but if held up in front of the sun's disc it would appear black. Of course it would not be black, nor would it be burning any less brightly than when looked at in a dark room, but compared with the sun's brilliance it would seem dark. So in the photographs given here the trees and people are not black, but only appear so against the sky

GOOD EXAMPLES OF THE RELATIVITY OF LIGHT

Here the bathers are seen, not against the bright sky, but against the sea in which the sky is reflected, and the result is the same as if the sky formed the background. They are all wearing bright bathing costumes, but these seem black when viewed against the light in the background. Were the photographer taking the picture in the other direction the details of the costumes would be seen

In this photograph the bathers are running along a ridge and their figures stand out clearly silhouetted against the bright sky. It is an ideal situation for a silhouette photograph. Indoor profile portraits of the silhouette kind may be obtained by placing a sitter side-face near a brightly illuminated translucent screen, and slightly under-exposing the plate. The face and head will then stand out black against a white background. Any boy or girl will find it interesting to try such photographs. The word silhouette comes from the name of Etienne de Silhouette, a French finance minister of 1759, who to replenish the exhausted Treasury practised all sorts of rigid economies. His name was transferred to the black type of portrait because that was very economical compared with a painted portrait. Years ago men at street-corners in London used to cut silhouette portraits out of black paper for a few pence

THE HIGHEST TIDES IN THE WORLD

When the tide has to run up a narrow channel, as for example the estuary of a river, the water gets piled up because, being unable to spread itself out it is squeezed together and forms what is known as a bore. One of the largest river bores in the world is to be seen in the estuary of the Severn, where the oncoming tidal wave rolls up like a wall of water nine feet high. The total rise of the tide in this estuary at the spring tide season is sometimes as much as fifty feet. On several occasions this bore has done much damage

The highest tide in the world is to be seen in the Bay of Fundy, between Nova Scotia and New Brunswick. Here the tide rises to a height sometimes of seventy feet, and rushes up the bay as a great surging wave, the height varying at different parts of the bay. At the mouth it reaches a height of eleven feet, but in the Noel River it is about sixty feet. This piling up of the water is due not only to the rushing up of the tidal wave, but also to the swaying to and fro of the whole of the water in the bay

WHY THE RIVER SEVERN HAS A BORE

In the open sea the tide or tidal wave due to the raising of the water by the attraction of the Moon, or Moon and Sun combined, is merely an up and down movement. Every particle of water in the ocean, even at the bottom of the sea, takes part in this motion. At the high spring tides the rise is only about four feet. In narrow channels and round coast lines, however, the tide causes a wave or current which moves backward and forward, and here we read something about this

THE height of the tide varies a great deal in different parts of the world, and indeed in different places which are not many miles apart. The form of the land and other causes lead to variations.

As we read in another part of this book (page 312) a great tidal wave is caused by the attraction of the Moon. This tidal wave moves fastest and rises least in the open sea, but as it approaches land two things happen: its speed is slowed down, and as a consequence its height is increased.

When it passes into a narrow channel or estuary this growing height of the tidal wave is still more emphasised. While in the open Pacific Ocean the tidal wave rises hardly two feet above the general level, in the narrow Bay of Fundy, between Nova Scotia and New Brunswick, it rises sometimes as much as 70 feet.

The Mediterranean and Baltic Seas, on the other hand, are almost tideless. This is chiefly due to the fact that their entrances are very narrow, while inside they broaden out very much. Their shape is indeed something like that of a bag with a narrow neck.

Astonishing Tides

The highest tide known anywhere in the world is that in the Bay of Fundy already referred to. For six hours the water rises and then during the next six hours it falls, and there are periods when the rise or fall is more than twelve feet in a single hour.

It was supposed until quite recently that this astonishing rise was due entirely to the fact of the tidal wave rushing up a narrow cul-de-sac: the water not being able to spread out in so narrow a bay was compelled to pile itself up, hence the very high tide. But careful investigations which have been made in recent years have shown that this is not the sole cause of the high tide in the Bay of Fundy.

We know how if we give gentle pushes to a child's swing it will gradually sway to and fro till at last it is swinging quite high. Well, this is what happens to the water in the Bay of Fundy. The tidal wave comes along and gives it a push, which sets it swaying. The water begins moving as the swing does. Some hours later the next tidal wave gives another push, and so the repetition of these pushes keeps the water in the Bay continually swaying to and fro.

It has been found by careful observation that the time taken for the water in the Bay to rock to and fro is just over twelve hours, and this corresponds to the period of the tides. The same thing is probably true of some other parts of the world, where the conditions are somewhat similar.

Even in England there are some very high tides. For instance, the highest spring-tide at Cardiff Docks rises 42 feet.

When the tide rushes up a narrow channel, it is called a bore, which comes from an old Norse word "bora," meaning "a wave." One of the biggest bores is found in the estuary of the Severn, where the tidal wave coming in from the Atlantic rushes up the Bristol Channel, the water being piled up till it forms a wall nine feet high, which moves up the estuary.

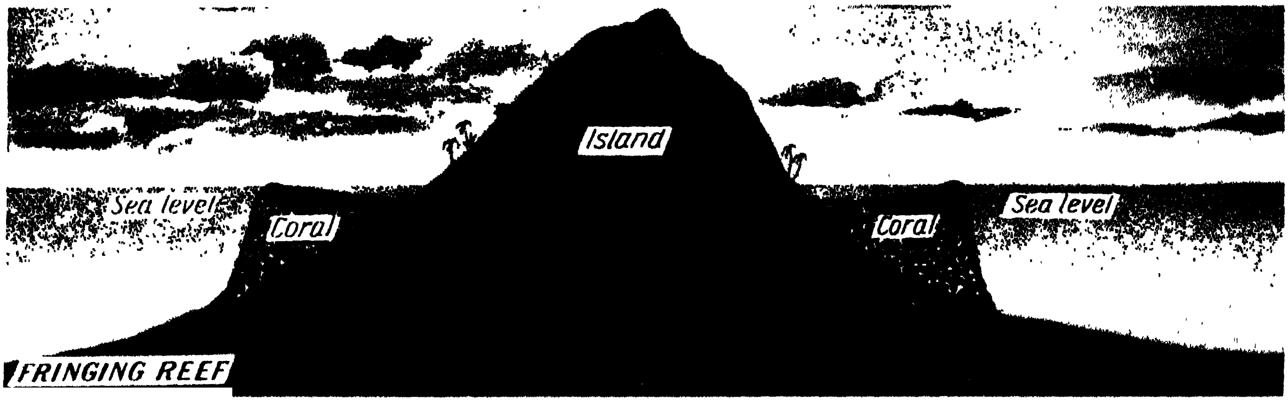
How the tides come round the coasts of the British Isles. The figures show the times of high tide at the new and full moon. The lines link up the parts which have high tide at the same hour

A Fifty-Foot Rise

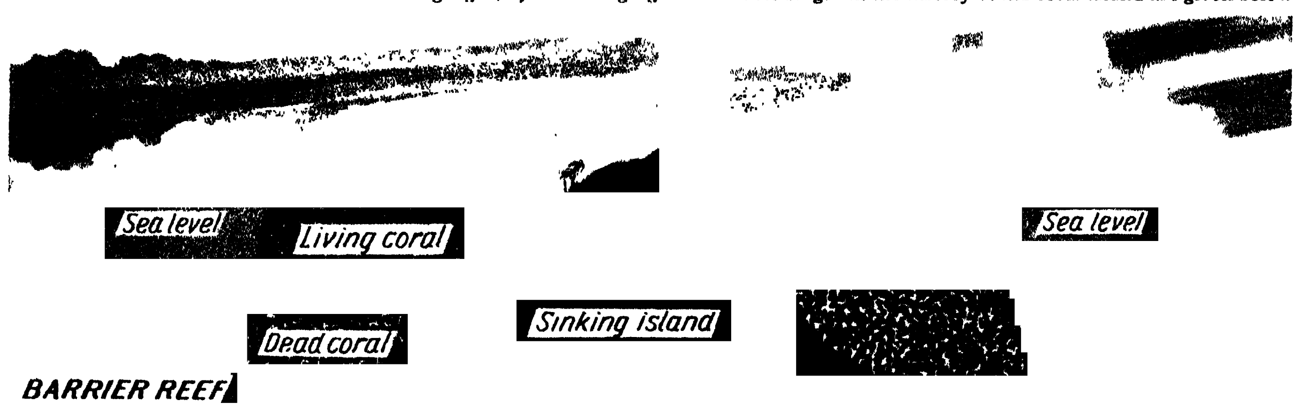
Sometimes it does so with such force as to do much damage. In 1883, for example, there was a particularly destructive bore in the Severn. The total rise of the tide at the spring tide season is sometimes fifty feet.

The piling up of the tide waters to form a bore is found in other parts of the world. There is a very marked bore in the River Amazon, and a similar phenomenon is found in the Ganges and in the big rivers that run into the China Sea and Yellow Sea. There is also a bore of considerable proportions in the River Seine in France.

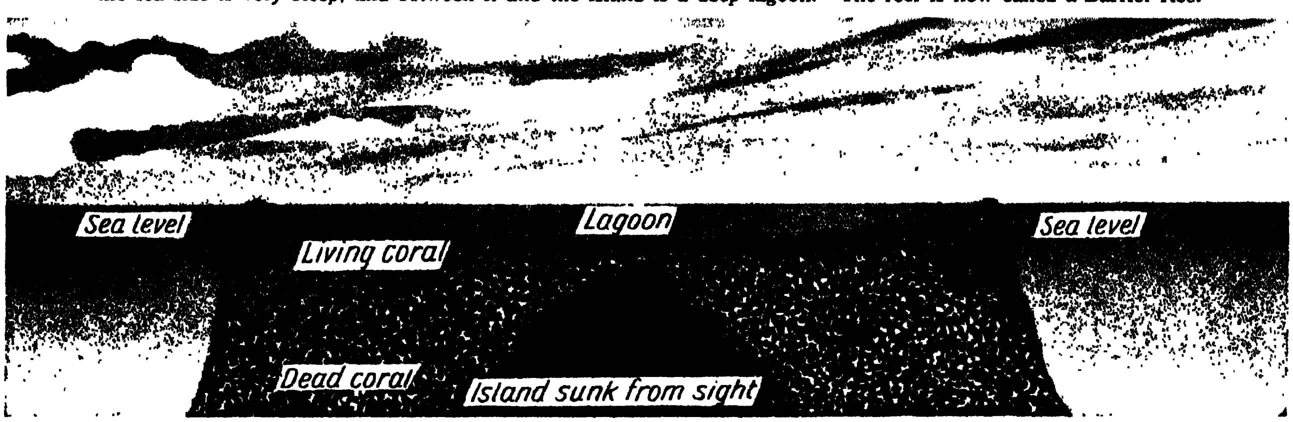
HOW A CORAL ISLAND IS FORMED



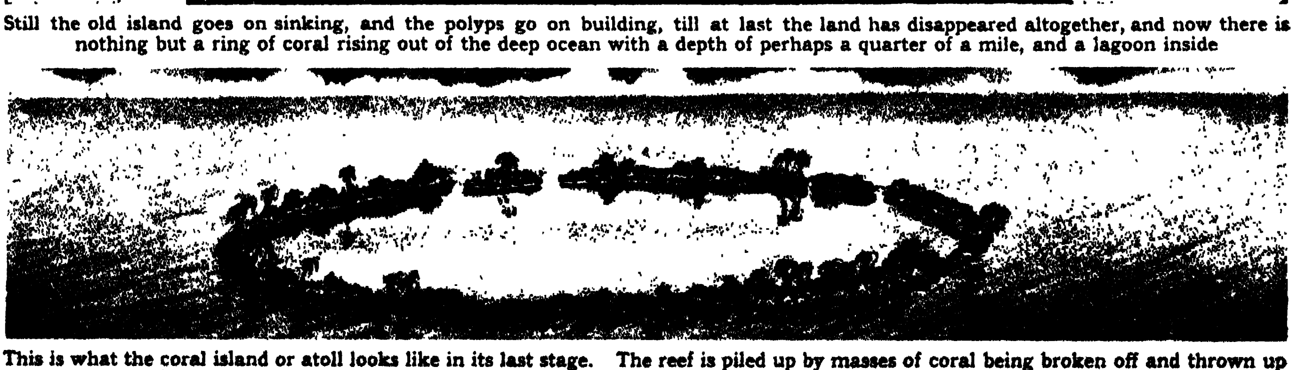
These pictures show how a coral island is formed, according to Darwin. First of all the coral polyps, which must live in shallow water, begin building their framework round a volcanic island near the surface. Gradually the island sinks, and as the polyps die fresh frameworks are built, until there is a hard mass of rocky coral forming a fringe round the old island, just below the surface of the water, as shown here. This is known to students of geography as a Fringing Reef. Later stages in the history of the coral island are given below



As the island sinks the coral polyps go on building up the reef, which now extends a considerable distance from the land. The reef on the sea side is very steep, and between it and the island is a deep lagoon. The reef is now called a Barrier Reef



Still the old island goes on sinking, and the polyps go on building, till at last the land has disappeared altogether, and now there is nothing but a ring of coral rising out of the deep ocean with a depth of perhaps a quarter of a mile, and a lagoon inside



This is what the coral island or atoll looks like in its last stage. The reef is piled up by masses of coral being broken off and thrown up by the waves. By weathering, the surface is broken up into soil, and vegetation begins from seeds washed ashore or dropped by birds

WHAT GOES ON IN A BEEHIVE

How many people who pass a beehive and see the bees flying to and fro and hear them humming realise the wonderful romance that centres around this insect community? With the exception of that of the ants, it is doubtful if any nature story is so remarkable and thrilling as that of the bees. Here is the story of what goes on in the hive

In a beehive there is a community of from 30,000 to 60,000 individuals so organised that every member has his or her duties, and where the work is so divided up and shared out that nothing is left undone.

There are foragers for food, gatherers of raw material, warehouse-men, scavengers, water-carriers, chemists, architects, manufacturers, undertakers and guards. There are those who see to the ventilation and heating of the hive and to its sanitary condition; there are those who look after the children, while others see that slackers and criminals are severely dealt with.

It is a wonderful story, and to give it in anything like detail would require a large volume. Here, however, we shall obtain some idea of how the bee lives and works, and how it justifies the practice of holding it up for emulation as an example of industry.

In order that we may follow the life of the bee community, let us think of a swarm of bees entering or being placed in an empty hive. What is the first thing the bees do? Well, they fly or climb to the roof of the hive and hang on by their claws. When every space is occupied other bees hang on to their fellows, and so at last there are festoons of bees hanging from the roof.

But all the bees do not join the crowd at the roof. Some crawl about examining the various parts of the hive, and if there is any rubbish lying about, such as twigs or leaves, they drag these out of the hive and make the place tidy. While they are doing this other bees remain on guard round about the entrance to keep out any strangers that do not belong to this particular community. Strange bees from other swarms or hives, if they tried to enter, would be stung to death.

How the Comb is Built

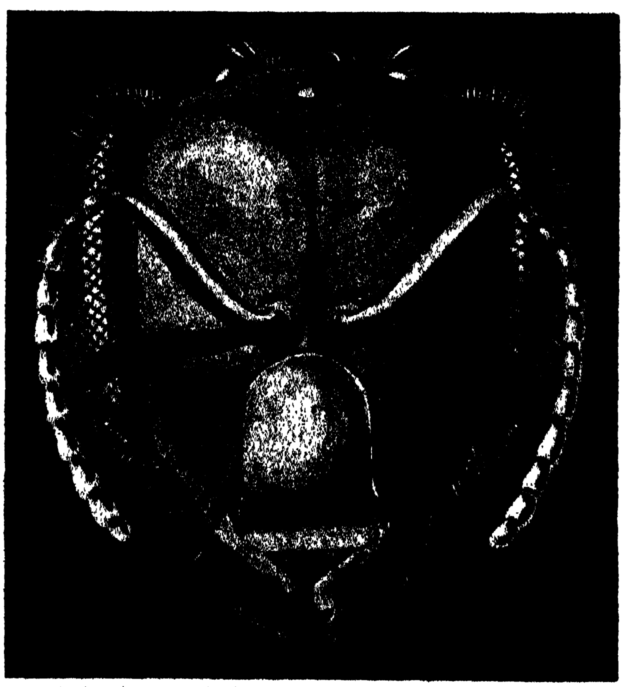
The first real business in organising the bee city is to build the comb in which the eggs will be laid, the young reared, and the honey stored. But before the building can start, the wax, of which the combs are formed, must be manufactured by the bees, and this is done by the workers. The abdomen of each is made up of six rings, and under these are eight little pockets. By means of certain glands the bee is able to make from honey a certain quantity of wax. It is not doing this all the time, but only when the wax is required.

Wax is produced in a fluid condition, and a temperature of from 87 degrees to 98 degrees Fahrenheit is necessary. This temperature the bees obtain by clustering together closely. The fluid wax is moulded and cools into little scales which are pushed out of the wax pockets. The scales look very much as if they were made of mica. The bee then removes each scale in turn by means of the pincers on its hind legs, transfers it to the front legs and passes the scale to its mouth, where the jaws chew it up and mix it with saliva till it is soft enough to be moulded.

All the workers hanging to the roof of the hive are busy producing wax, and this they do in silence. First one plate of wax then another is attached to the roof of the hive till at last there is a piece of white wax hanging. This is the foundation of the comb, for the bee, unlike ourselves, who build upward from the ground, builds downward from the roof.

One after another the bees contribute to this supply of wax, and then architect bees shape the first cells, hollowing them out in a hexagonal or six-sided shape and placing them back to back. All the time more and more wax is being produced, and at last a large comb with many cells is ready. Neither the queen nor the drones possess the apparatus for making wax, and they do not, therefore, take part in this work.

It must be explained that in bee-keeping the wax is provided by the



The left-hand picture shows a magnified view of the queen bee's face and the right-hand picture a drone's face. The lattice work parts at the sides are compound eyes with many facets, the round spots are simple eyes, and the antennæ or feelers are in front

human owner, who places frames containing wax in the hive. This saves the bee the trouble of making the wax. But the bee-keeper does not do it because he loves the bees; he does it to save the honey, for the bee makes wax out of honey and uses from ten to fifteen pounds of honey to produce a single pound of wax. Therefore it pays to give the bees their wax, so that they may get on with the business of producing honey for their owner.

The six-sided form of cell is wonderfully ingenious, for it gives the maximum of strength and economises space, the cells fitting closely to one another without any waste, as there would be if the cells were circular. If they were square they would not be so strong.

The bees leave nothing to chance. Most of the cells are prepared for the hatching of worker bees, and these are each about a fifth of an inch in diameter. A few are prepared for the hatching of drone bees, and these are made a little larger; while for the rearing of queens quite a different type of cell is prepared. Queen cells are much bigger and hang with their openings downwards.

The Queen and her Attendants

In order to make room for these queen cells, of which there are three or four, part of the ordinary comb is cut away. In the early stages of the cell-building the queen wanders aimlessly about the hive, but as soon as there is a sufficient number of cells she begins her work, which is to lay eggs. Attended by a number of other bees who might almost be regarded as ladies-in-waiting, she selects a cell and lays the first egg. But before doing so she examines it well, and only places the egg inside when she is satisfied.

The attendant bees wait round in a circle. Then the queen moves to another cell and lays another egg, and so she continues. She seems to carry out her duties day and night without any rest, and all this time her attendants keep her fed, clean her, and apparently encourage her by stroking her with their feelers.

It is now a race between the queen and the cell builders, and if the architects were not very busy they would be overtaken by the queen laying the eggs. At last all the cells have been supplied with eggs, and now those which were first laid begin to hatch out. It takes three or four days for the egg to hatch, and at first the bee is a small white grub which is immediately fed by bees acting as nurses.

Just as human babies do not at once begin eating meat, so the newly hatched bee grubs are not fed on honey but on a kind of bee milk produced by the nurse bees from glands in their bodies. They turn ordinary honey into this bee milk, the proper name of which is chyle food, a word from the Greek which simply means juice.

After about three days the food supplied to the little grubs is changed, and a richer form of bee milk is given to them. The grub grows rapidly, casts its skin several times, and is then ready for the next stage of its existence. As soon as it is full-grown as a grub or larva, the workers come along and seal up the cell with wax and the grub then spins a cocoon of silk in which it soon begins to change into a chrysalis or nymph as it is called.

Then all sorts of alterations take place. The head develops, the mouth

The sting of a bee in its sheath, on the left, magnified and placed for comparison by the side of a needle's eye

regains form, the division becomes very marked between the head, thorax and abdomen, little projections appear and develop into legs and antennæ, and the wings and sting become visible. Then the eyes are seen and the body which has hitherto been white acquires colour, and in sixteen days from the closing of the cell the grub has become a perfect worker bee, and is ready to come out.

With its sharp jaws the young bee cuts a hole in the wax door and puts out

The hind leg of a bee, magnified, with the pollen basket seen here as a depression in the joint shown on the right

an antenna, waving it about as though feeling its way. Then it goes on cutting the hole bigger until at last, assisted very often by the nurse bees, it comes right out, a pale, weak creature, but almost ready for work. The nurses clean and feed it or perhaps we should say her, for every worker is a female bee; it is only the drones that are males.

In a few hours the newly hatched bee gets to work and herself becomes a nurse feeding other newly hatched grubs. Then after a couple of weeks of this kind of work she joins the army of foragers that go out hunting for nectar and bring it back to the hive from the flowers.

The birth of a drone bee is almost the same, except that he takes twenty-five days to change from the egg to the perfect insect.

One of the wonderful things about the worker bee with her manifold duties in the complicated communal life of the hive, is that she is born with all this knowledge. She does not have to learn to do things as do boys and girls. In other words, she may be said to be born educated. There is no school and no apprenticeship necessary. That is why we must not attribute the bee's marvellous skill to intelligence. All its skill is with it from birth.

Nursing the Princesses

The queen bee's story is different. Queen is rather a foolish name for the bee that is really the mother of the hive. She does not rule the community in any way. It has already been explained that the architects make cells of special shape, size, and position for the hatching of the princesses who will later on become queen bees, though before they become the mothers of new communities they may be slain in rage by the old queen with the help and consent of the workers.

There will probably be three or four of these queen cells and they are better ventilated than the ordinary cells. As soon as they are ready the nurse bees take an egg from one of the worker's cells which is not more than three days old, and place it in one of the queen cells. They do the same with the other queen cells. Four days later the first egg hatches out into a grub.

Now a wonderful thing happens. Instead of feeding it on the ordinary chyle food supplied to worker grubs, the nurses feed the grub in the queen cell on a specially rich kind of food which is only given to grubs that are intended to develop into queens. On the ninth day the grub spins a cocoon and the cell is then closed up. A week later the young princess is ready to leave the cell, and she cuts her way out, after which the architects get busy and fill up the large cell by constructing in its place a number of smaller cells for the storage of honey. The wax of the old cell is used in the construction of these new ones.

The marvel of the whole business, a matter not yet understood by scientists, is that the bees by taking an ordinary egg, housing it specially, and feeding the ordinary grub on special food, can produce a special kind of bee capable of laying many eggs that will develop into a new bee community. Thus we see how the wonderful community is produced and grows up.

The work of honey-gathering is described in another part of this book.

THE MARVELLOUS ACTIVITY INSIDE A BEEHIVE

In this picture of a beehive the artist has cut away the front and side to show us what goes on inside. On being placed in a hive many of the bees go to the roof and hang there producing wax for the comb. In modern hives, however, the wax is placed in the hives in frames, and this saves the bees the trouble of making it, and gives them more time for producing honey. The wax is shaped into hexagon cells, and in them the queen bee lays the eggs, some of which produce drones or male bees, but the majority worker or female bees. A few cells are enlarged, and these are for producing queen bees. When the eggs hatch out the young grubs are fed on bee milk, produced by nurse bees. Some eggs, however, are taken out from the worker cells and put in the queen cells. When these grubs hatch out, instead of being fed on ordinary bee food, they are supplied with a special rich kind of food, and this apparently changes them into queen bees. Special bees act as architects to shape the cells, others wait upon the queen, and others act as nursemaids. Some bees stand outside the hive to act as guards, and others act as scavengers, removing from the hive insects that may die and other refuse

THE OLDEST OF ALL THE FIBRE PLANTS

Flax was the earliest of all the plants to be cultivated by man for its fibre. It would undoubtedly have remained the most important fibre plant had it not been for the discovery of America and the cultivation of cotton on a large scale with cheap labour, which made it cheaper than flax. Indeed, it was not until the nineteenth century that flax surrendered the first place to cotton. Here are interesting facts about flax.

Flax is still a very important commercial plant, and is cultivated for its fibre, from which we make linen, and for its seeds, from which we get linseed and linseed oil. Large quantities of flax are grown in Ireland, and formerly there were many acres under cultivation in Great Britain, but in recent years the growing of flax has decreased steadily in Great Britain, although King George V re-introduced its cultivation in East Anglia, and grew crops of flax at Sandringham. In Russia millions of acres are grown, and there are also hundreds of thousands of acres given up to flax in other parts of the continent of Europe.

No one can say where the flax originally came from, but it probably grew wild in Assyria and in the Nile Valley long before it was cultivated. Nowadays, however, it is nowhere really a wild plant, although in England and elsewhere it is found growing wild, but in every case it has escaped from the fields.

How ancient the use of flax fibre is, is proved by the fact that the early Egyptian mummies are wrapped in linen cloths, and we find pictures of the growing flax plant carved on the tombs of Ancient Egypt.

A Soft Fabric

That it was an article of luxury is proved by the references in the Bible to the splendour of kings, who are described as being "clothed in purple and fine linen"

Of course it makes a much finer fabric than cotton, and when woven and bleached has a snowy whiteness and a silky lustre that has always made it very attractive. In fact, finely woven linen is a very beautiful and soft fabric

The cultivation of flax must have very early passed into Europe, for we know that the Lake Dwellers of Switzerland, who lived in the Stone Age, grew and wove the fibre.

The higher cost of linen over cotton is due not only to the greater expense of growing and harvesting the crop, but also to the fact that in the after-processes there is much more hand-work needed than in the case of cotton; although much flax and linen processing is now done by machinery.

Flax grows as a delicate branched plant two or three feet high, and it has narrow, long leaves, which are opposite to one another on the stem. Numerous pale blue flowers are produced, and these develop into round five-chambered capsules, each chamber containing two seeds. Longfellow refers to the dainty blue flowers of the flax plant when in his poem, "The Wreck of the Hesperus," he says of the skipper's little daughter, "Blue were her eyes as the fairy flax."

Flax needs a heavy, rich, well-drained loam soil, and the seeds have to be hand-sown and the plants hand-weeded. It also has to be gathered by hand, handfuls being pulled up and then laid out on the ground for drying. To get the seeds out, the worker takes a handful at a time and draws the heads through a fixed comb, the capsules rolling off as the plants are drawn through the teeth.

The stems are then retted, that is, they are either laid out in the dew and rain, or placed in pools of soft water. The stems rot and the fibre falls to the bottom. This process takes about a fortnight, and throughout it there is a very offensive smell from the water

The flax stems are then spread out in rows to dry, and then they are broken between rollers and scutched or beaten by wooden blades to separate the woody matter from the flax. After being finally cleaned the flax is baled and sent to the market.

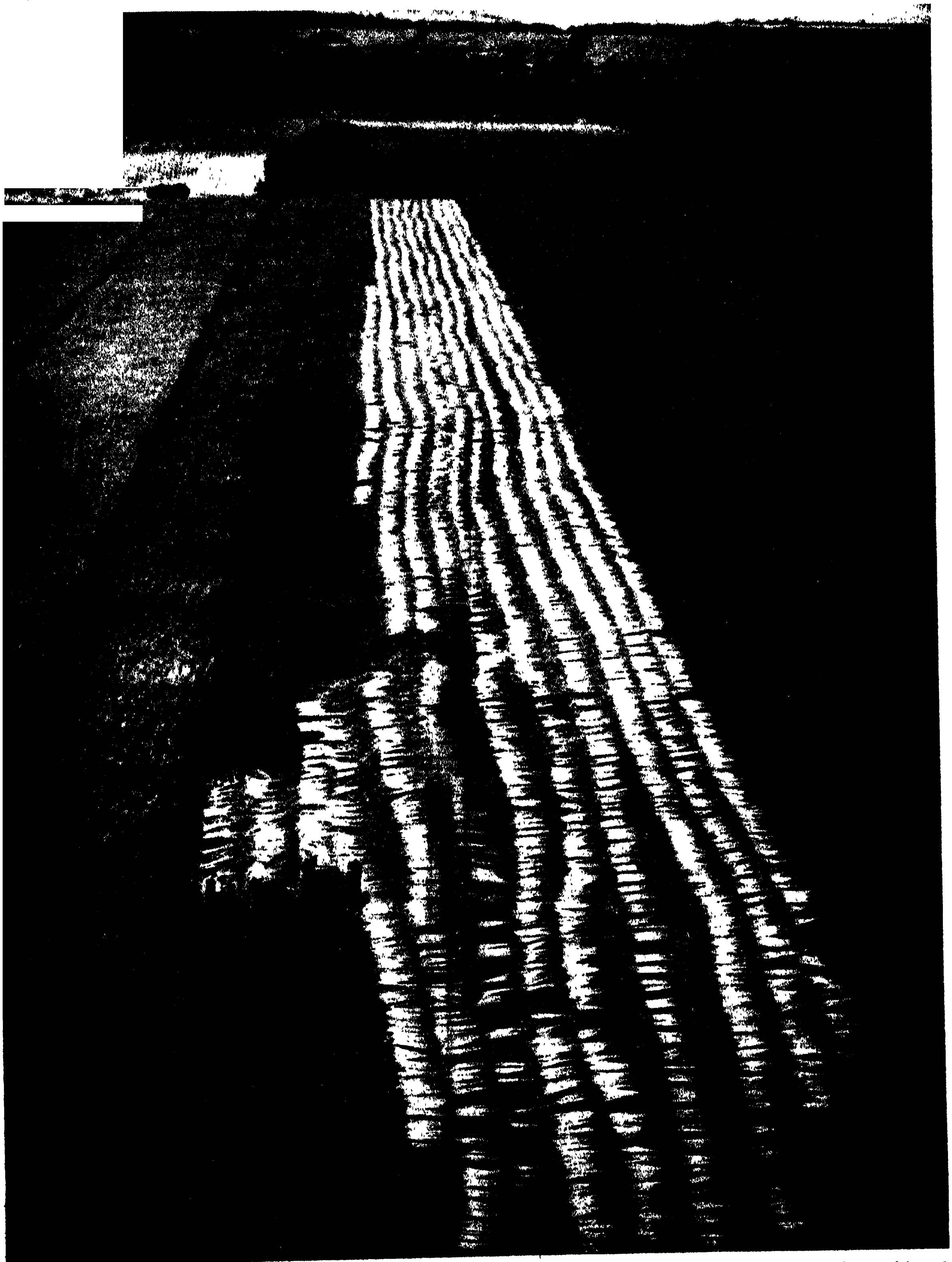
Fine and Strong

A single fibre of flax may be over a foot long, and though one of the finest of fibres, it is stronger than any other.

When flax is cultivated chiefly for its fibre it is harvested before the capsules have ripened. But if the crop is wanted for the production of linseed meal and oil, then the capsules are allowed to get ripe, when they change from green to brown. The stalks of the plant have then become yellow. Although the plant is harvested by hand-pulling when required for fibre, in countries like America, where it is grown extensively for the seed, it is harvested by machinery.

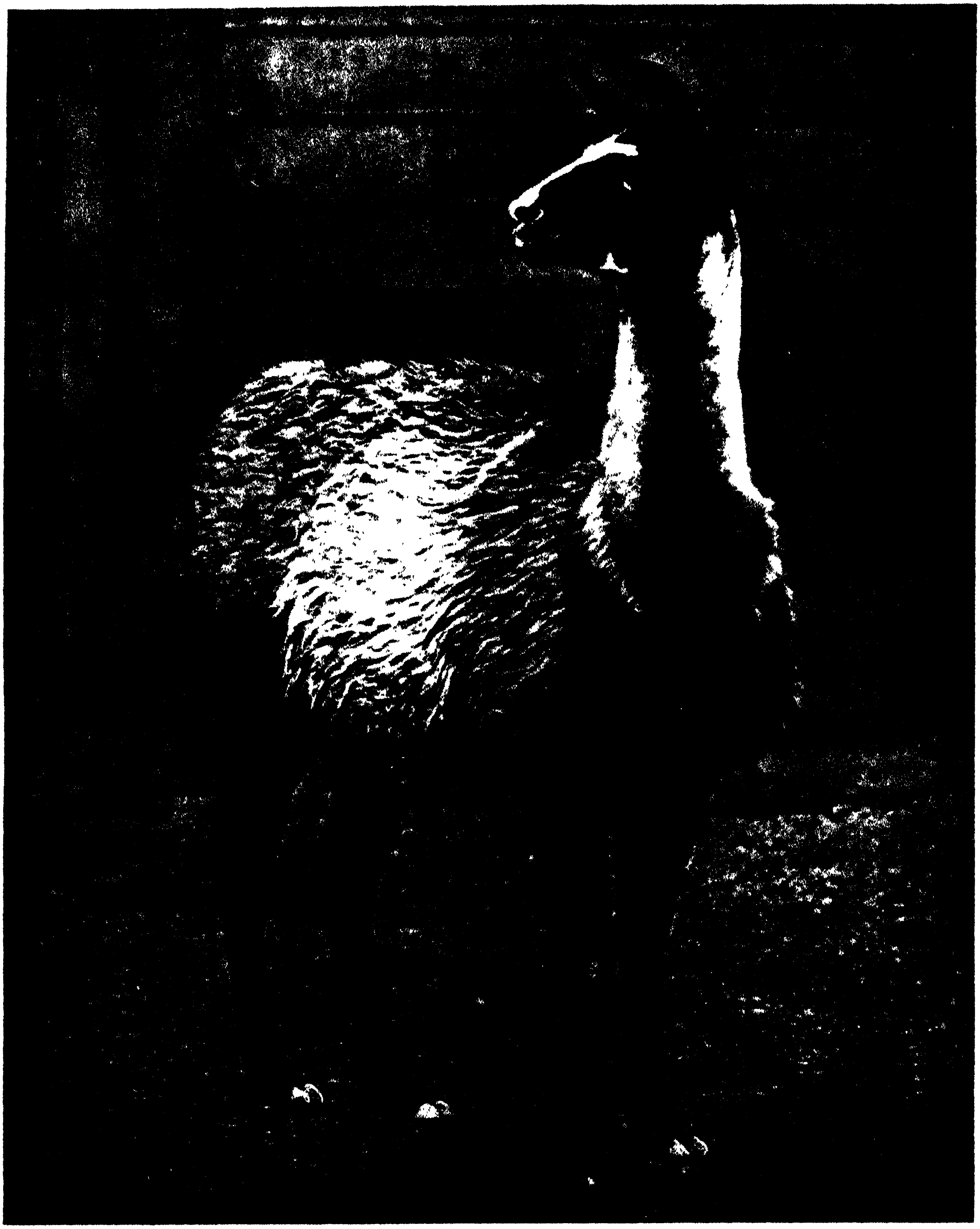
The flax plant, its different parts, and various stages in its growth

DRYING THE FLAX FROM WHICH WE MAKE LINEN



Flax, which was the earliest plant to be cultivated for its fibre, is grown extensively in Ireland and has in recent years been cultivated in East Anglia. The fibre is obtained from the stems, and these are gathered by hand and laid out to dry, as shown in this photograph taken on the Royal estate at Sandringham. The seed from which we obtain linseed meal and linseed oil is threshed out and the stems then go through a process known as retting. They are steeped in soft water, when the stems decompose and the fibre sinks.

THE CURIOUS CAMEL OF SOUTH AMERICA



The llama—not to be misspelt lama, which means a Tibetan Buddhist priest—is the camel of South America. It is smaller and lighter in build than its relations the Old World camels, and has no hump. The llama can live only in cold or temperate regions, and while in Patagonia it thrives on the plains, farther north it lives high up in the Andes. Near the equator it is found three miles above sea level. There are two wild breeds of llama, the larger known as the guanaco and the smaller as the vicuna. The domesticated llama, bred as a beast of burden like the horse and ass, is a guanaco. The llama has a nasty habit, when annoyed, of spitting at people

ROMANCE of BRITISH HISTORY

THE LAST BATTLE FOUGHT IN ENGLAND

Here is the dramatic story of the last rebellion in England and the last real pitched battle ever fought on English soil. It ended in disaster for the rebels and the Judge who tried the prisoners has come down in history as the cruellest and most dishonest judge who ever sat on the English bench

THE Stuart Kings had always been a trouble to England, and the country never did anything better than when it sent the last of them packing to the Continent.

When James the Second mounted the throne he was mistrusted by many of his subjects. His religion was not that of the national Church, and it was believed by many that he intended to restore the old faith of the days before the Reformation.

But the great mass of the nation was willing to give him a chance. The doctrine of the Divine Right of Kings was still held firmly by many people, and when, soon after James assumed the crown, there was a plot to place his nephew the Duke of Monmouth on the throne it was only in a few districts that there was any sympathy with the project, although Monmouth himself had always been very popular.

He was the son of Charles the Second, and some attempts were made to prove that Charles had married his mother, but this was not true, and therefore he had no right whatever to the throne of England.

Monmouth was quite willing to lead the conspirators, and on the morning of June 11th, 1685, he landed from Holland at the little port of Lyme Regis in Dorset, with a few followers and a quantity of arms. There were three ships, and as soon as Monmouth went ashore he commanded silence, kneeled down on the beach, thanked God for having preserved the friends of liberty and pure religion from the perils of the sea, and implored divine blessing on what was yet to be done by land. He then drew his sword and led his men over the cliffs into the town.

It seemed quite a good beginning, and the people of the district soon flocked to the blue standard which Monmouth set up in the market place of Lyme. Within twenty-four hours he was at the head of a force of 1,500 men, but, of course, these were not trained soldiers. They consisted of ploughmen and tradesmen, and their officers were mostly squires and lawyers.

Monmouth decided to lose no time in striking a blow, and hearing that a force of militia had been gathered at Bridport to oppose him, he resolved to march to that town. But just as he was preparing to do so an unfortunate quarrel occurred in which one of his supporters from overseas shot a recruit dead, because the man had resented the seizure of his horse.

The people were very angry at this murder, and the assailant, who was an able officer, had to return to his ship, so that Monmouth lost his services.

The Duke of Monmouth at the Battle of Sedgemoor. From the painting by Wyck

The next day the Duke sent a force of 500 men to attack Bridport, and there was an indecisive fight. This was not surprising, for both forces consisted of yokels not specially trained for warfare, and neither side knew how to snatch victory from the other.

Monmouth's force withdrew once more to Lyme Regis, where recruits were coming in by hundreds. Arming and drilling went on constantly, but what was disquieting was that none of the gentry of the district would serve under the blue standard.

Word had been sent to London of the landing of the Duke, and the gathering of his forces, and meanwhile the Duke of Albemarle, who was Lord Lieutenant of Devonshire, began to march towards Lyme with 4,000 militia.

At Axminster he found the insurgents drawn up with four cannon to oppose him, and fearing that the popularity of the Duke of Monmouth, if he should show himself, would cause the royal troops to desert, he decided not to fight, and at once began to retreat. Monmouth's men followed and the retreat soon became a rout, for Albemarle's men who, if they had been resolute, could easily have crushed the rebellion, threw their arms and uniforms away and fled as fast as they could, without striking a single blow. Had Monmouth been smart he could have gone forward and taken Exeter, but he thought it was better to give his men further training, and so marched towards Taunton, where he arrived on June 18th, just a week after landing.

In London the King and Parliament were not idle. The House of Commons met and brought in a Bill making Monmouth guilty of high treason. It also voted money to the King for the suppression of the rebellion and troops were at once dispatched to deal with the insurgents.

At Taunton Monmouth was well received. The people welcomed him with transports of joy, the houses were decorated, and no man dared show himself in the streets without wearing a green bough in his hat, the badge of the Duke's cause. Girls of the best families in the town wove colours for the insurgents, and one flag was embroidered with emblems of Royal dignity, and was handed to Monmouth

himself. The lady who headed the procession with the flag presented the Duke with a Bible, and this he took with a show of great reverence, declaring: "I come to defend the truths contained in this Book and to seal them, if it must be so, with my blood." How he carried out this pledge we shall see later.

Although the common people flocked to his standard, there was still no sign that the upper classes had any sympathy with him, and this disturbed the Duke a great deal. His force consisted of day labourers, small farmers, shopkeepers and apprentices, but not a single peer, baronet or knight, or even a Member of the House of Commons, had joined him.

So far Monmouth had not declared himself King. It must be remembered that even if James were to vacate the throne the next heir was his daughter Mary, who was married to William Prince of Orange, and as she and her husband were Protestants there could be no question of disability on the ground of religion.

"King Monmouth"

But now, badly advised by one of his chief supporters, Robert Ferguson, Monmouth allowed himself to be proclaimed King in the market place at Taunton. As his name was James, and there might be some confusion if he were proclaimed under the same title as the rightful monarch, he was called by the strange name of King Monmouth.

The Pretender at once began to issue Royal proclamations, and very foolishly set a price on the head of his rival, James the Second. He also declared the Parliament that was sitting at Westminster to be an unlawful assembly, and ordered the Members to disperse. A third proclamation forbade the people to pay taxes to James.

All this was very foolish, seeing that only a week before Monmouth had solemnly bound himself not to take the crown till a free Parliament should have acknowledged his rights.

On the next day the Pretender marched from Taunton to Bridgwater, but his spirits were not high, and his gloom depressed his followers. At Bridgwater he was received by the Mayor and proclaimed as King in the market place. The town was very enthusiastic, and his troops were given excellent quarters and furnished with all they needed at little cost

But Monmouth had good cause for disquiet, for the Royal forces were now gathering all round, and John Churchill, afterwards the victorious Duke of Marlborough, was marching west with a force of regular soldiers, while other regular troops were also on the way.

Monmouth now advanced from Bridgwater and marched to Wells, and then to Shepton Mallet, but he seems to have had little definite plans, and all the way he was harassed by Churchill and his regular troops.

Then he decided to march to Bristol, where he had many supporters But he delayed the attack too long, and

Monmouth mounted the steeple of the parish church and through a telescope looked at the enemy

soon part of the King's forces came up and scattered some of the rebel horse.

Monmouth seems now to have been in great doubt as to what he should do. He went to Bath and summoned that city to surrender. But as it was strongly garrisoned for the King and Royal troops were also approaching from several directions, he decided to do nothing. Soon afterwards the advance guard of the Royal troops attacked Monmouth, but as they were met with a sharp fire they retired, and for a time neither side seemed anxious to come to action.

Rain now began to fall in torrents, and the roads became quagmires, making movement difficult Promised forces from other counties did not arrive to join the rebel army, and Monmouth began to realise that his army of ill-armed yokels, enthusiastic though they might be, would be able to make no stand against regular troops.

He now began to blame his advisers, who had induced him to leave his happy retreat on the Continent, and proposed to abandon his faithful followers and steal away with his chief officers to some seaport, where he could escape to the Continent once more.

He seriously discussed this scheme with his leading advisers, but while some listened favourably, there were others who denounced the dastardly cowardice of it, and the scheme of flight was abandoned for the time being.

But what could the Duke do? With well-armed troops closing in upon him, he found his own men, armed largely with flails, bludgeons and pitchforks.

Leading a Forlorn Hope

While Monmouth was wavering between various projects the King's forces, consisting of 2,500 regular troops and 1,500 militia, came near On Sunday morning, July 5th, they pitched their tents on the plain of Sedgemoor, about three miles from Bridgwater. Monmouth, who had returned to this town, mounted the steeple of the parish church, said to be the loftiest in Somerset, and commanding a wide view over the surrounding country, and through a telescope looked at the enemy.

He was very gloomy as he looked out on the scene, and well he had cause to be. He could distinguish among the Royal forces a gallant band of hard fighters known as Dumbarton's Regiment, whom he knew well.

"Ah," he said, "I know those men. They will fight. If I had but them all would go well."

Spies who had been sent out reported that the men of the Royal forces were drinking heavily, and Monmouth therefore decided to make a night attack at once.

When darkness fell, although there was a full moon, the fog lay thick on Sedgemoor, and nothing could be discerned at a distance of fifty paces. As the clock struck eleven, the Duke with his bodyguard rode out of Bridgwater Castle and led his army by a

roundabout path nearly six miles long towards the Royal camp on Sedgemoor.

He himself commanded the foot soldiers, while he entrusted the horsemen to Lord Grey. Orders were given that there should be the strictest silence during the march. Not a drum was to be beaten and not a shot fired.

By one o'clock in the morning of Monday, July 6th, the rebels had reached the open moor, and between them and the Royal army lay three broad streams filled with water and soft mud. Two of these Monmouth knew he had to cross, but it seems strange that the third, immediately in front of the Royal camp, had not been mentioned by any of his scouts, and that its existence was unknown.

The first brook was passed easily by a causeway, but there was some delay in getting over the second owing to the guide missing his way in the fog. In the confusion a pistol went off, and some men of the Royal Horse Guards, who were on the watch, heard the report and very soon found that a large body of men was advancing through the mist. They fired their carbines and galloped off in different directions to give the alarm

At the Third Brook

The Royal drums beat to arms and the men got ready for the attack. Monmouth, who had drawn his army up for action, ordered Lord Grey to lead the way with the cavalry, and himself followed with the infantry. Suddenly the rebels found their progress unexpectedly stopped by the third brook, on the opposite side of which the King's Footguards were forming in order of battle.

"For whom are you?" called out an officer of the Guards.

"For the King," replied a voice from the rebel cavalry.

"For which king?"

"For King Monmouth," came the shout, mingled with an old war cry of the Parliamentary army, "God with us!"

This was the signal for the beginning of the last pitched battle ever fought on English soil.

There could be little doubt as to the result. What possible chance had a mob of yokels, largely armed with farm implements, against a well-equipped force of regular soldiers, under a leader like John Churchill, later to be the great victor of Blenheim and Ramillies?

The Royal troops fired a volley of musketry, which sent the rebel horsemen flying in all directions. Not only had Monmouth's cavalry never fought on horseback before, but their horses, mostly from the plough, had never even been trained to obey the rein, let alone to stand fire.

The battle was already won, for the Duke's horsemen were dispersed all over the moor. The infantry, however, came up, but they too were stopped by the waterway, which divided them from the Royal camp. The only possible chance the Pretender had ever had of victory, that of winning by a surprise, had been lost when the pistol went off prematurely.

What could the unfortunate insurgents do? They came to a halt on the edge of the brook, and the Royal infantry opposite fired into their ranks for three-quarters of an hour. We are told that the Somerset peasants behaved as though they had been veteran soldiers, but in returning the Royal fire they invariably levelled their pieces too high, and so did little damage.

Meanwhile King James's Life Guards and the Blues had come upon the scene and scattered what remained of Monmouth's cavalry—if such a name can be given to the untrained yokels mounted on farm horses. The unfortunate fugitives as they ran spread panic among the ammunition drivers in the rear, and the wagoners drove off their carts and never stopped till they were miles from the battlefield.

Up to this point Monmouth had behaved well. Pike in hand he had led his infantry on foot, but he was too good a soldier not to know that his cause was lost. Both his cavalry and the ammunition wagons had gone, while the King's forces now united, were in good order, and flushed with the initial success.

The Life Guards attacked the insurgents on the right, and the Blues on the left, but although the Somerset yokels, now without ammunition, fought like Trojans with their scythes and the butt ends of their muskets, they could do nothing against the well-trained cavalry and the artillery of the King.

"Ammunition! For God's sake, ammunition!" was the cry heard from the rebels, but soon their ranks broke under the fire from the guns, and then the King's cavalry charged once more and carried everything before them. In a few minutes all was over

At length, soon after sunrise, a gaunt figure was seen hiding in a ditch. It was Monmouth

The End of the Battle

More than 1,000 of the rebels lay dead on the moor, while only 300 of the soldiers had been killed or wounded. Thus ended the last battle ever fought on English soil. It was memorable for still another reason. It was the last time a prelate of the Church contributed to a victory in an English battle.

The Bishop of Winchester, who had been very energetic for King James, when he found there was some difficulty in dragging the guns to the place where the battle was raging, offered his coach horses and traces for the purpose, and this interference of the prelate had a good deal to do with the speedy victory of the King's forces.

The tragedy of Sedgemoor, however, was not the battle itself, it was what took place afterwards. James was merciless in punishing the rebels, hundreds of whom were rounded up and held for trial. The King sent down the wicked and notorious Judge Jeffreys, one of the biggest scoundrels in the annals of British history, and a

worthy tool of his cruel master There was no attempt to give any of the prisoners a fair trial Juries were bullied into finding verdicts of Guilty, and hundreds of victims were hanged in places where they could be seen by their neighbours.

In all English history there is nothing quite so bad as the behaviour of Judge Jeffreys in the West Country He even sentenced to be burnt the aged and charitable Lady Alice Lisle. Her only crime was that of harbouring two of the rebels, and although all the evidence pointed to the truth of her statement that she did not know the refugees were rebels at all, Chief Justice Jeffreys so stormed and bullied that the jury were forced to find a verdict of Guilty

When the jurymen remained long in consultation the Judge sent a message to tell them that if they did not instantly return with their verdict he would lock them up all night. They came into the court declaring that they doubted whether the charge had been made out, but Judge Jeffreys then threatened them so vehemently and frightened them so badly that they at last gave a reluctant verdict of Guilty.

A Cruel Sentence

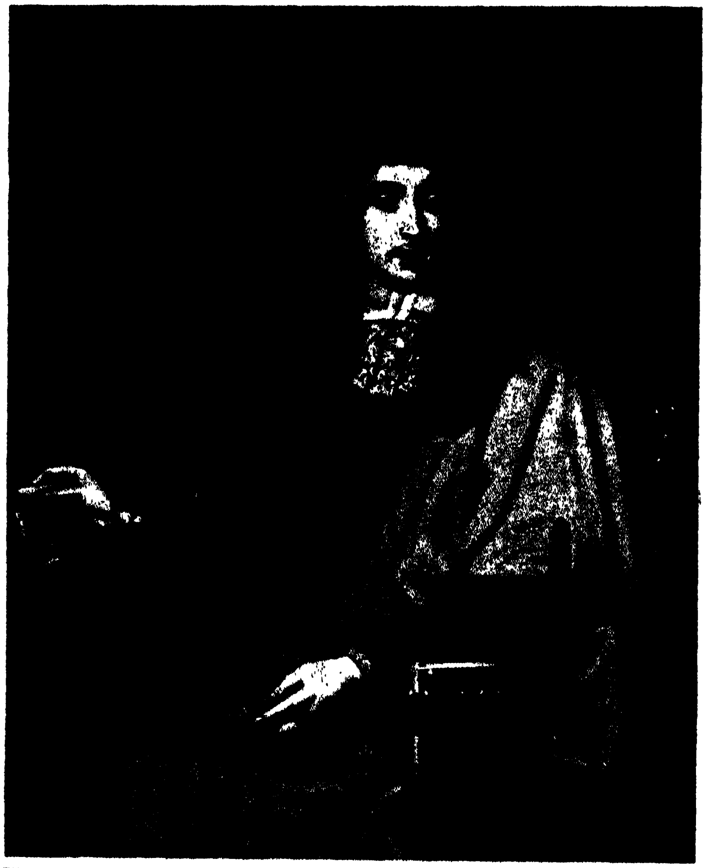
Next morning the Judge condemned Alice Lisle to be burnt alive that very afternoon. The clergy of Winchester Cathedral, though loyal friends of the King, remonstrated, and at last the Judge agreed to put off the execution for five days. During that time the condemned woman's friends begged the King to show mercy, and ladies of high rank interceded for her. Even the King's brother-in-law pleaded her cause, but all was in vain. James did not know the meaning of the word mercy, and the most that could be done was to get the sentence commuted from burning to beheading. The gentle and charitable old lady was put to death on a scaffold in the market place at Winchester, showing the greatest courage as she died.

It is worth mentioning that another woman who had harboured a rebel in London was actually burnt to death at Tyburn.

In addition to the hundreds put to death by hanging, nearly a thousand were sent as slaves to the plantations in the West Indies.

Jeffreys, as a reward for his villainy, was on his return to London made Lord Chancellor by the King. But when James fell a year or two later, and Jeffreys tried to flee the country, he was caught at Wapping disguised as a sailor and sent to the Tower of London to save him from being torn to pieces by the mob. There he died miserably a few months later, and left behind perhaps the blackest name in all English history.

What happened to Monmouth ? Like all the Stuarts he proved unfaithful to his friends and followers. When he saw the battle of Sedgemoor was lost he coolly slipped away with a few friends, determined to make his way to France.



The notorious Judge Jeffreys who behaved so cruelly after the Monmouth rebellion. From the painting in the National Portrait Gallery

Within a few hours he was twenty miles from Sedgemoor, his luckless followers being left to their fate.

After wandering for some time the horses failed, and the fugitives, disguised as rustics, proceeded on foot towards the New Forest. They passed the night in the open air. The next morning Lord Grey was captured. Then a yokel with whom Monmouth had exchanged clothes was discovered, and the search for the Pretender was redoubled. A sum of £5,000 was set upon the Duke's head, and the prospect of the reward stirred the zeal of the searchers. Every man who did his duty in the search, it was agreed, should have a share of the promised £5,000.

At length, soon after sunrise on the following morning, a gaunt figure was seen hiding in a ditch. The pursuers seized their prey, who was trembling greatly and seemed unable to speak. His pockets were searched, and in them were found some peas which he had gathered in his hunger, a watch and a purse of gold, together with a jewel which had been given to him years before by his father Charles the Second. Clearly this was Monmouth, but who that had seen him in the days of his glory could believe that this dishevelled, trembling, starving fugitive was he ? He looked anything but a prince.

His true character was soon revealed. He wrote to the King a letter full of craven fear, which was shameless in the way that it blamed others for inducing him to make himself King. He begged piteously that James would grant him an interview, and pretended he had a secret of great importance which he could impart to no one but the King.

Abject Pleading

James did see him. The prisoner was taken into the King's presence with his arms bound behind him with a silken cord. Immediately he threw himself on the ground and crawled to the King's feet. He wept and tried to embrace his uncle's knees with his pinioned arms. He begged for his life at any price. He owned that he had been guilty of a great crime, but he tried to throw all the blame on his friends.

He pleaded the ties of kinship, he appealed to James's love for his late brother, and repeatedly implored the King to show mercy to him. But there was never a plea for mercy on behalf of the faithful but deluded followers who had been led to support him.

James replied that the repentance had come too late. Then Monmouth meanly offered to change his religion if his life could be spared, but James would hear of nothing. And a day or two later Monmouth's head was cut off on Tower Hill. Once all hope of saving his life was gone, however, he seems to have resigned himself to his fate and certainly, in the end, faced the headsman bravely.

We cannot blame the King for executing his nephew. But the name of James the Second will be execrated for ever for his vindictive cruelty among the deluded insurgents of the West Country.

THE GREAT WHEELS OF A LOCOMOTIVE

There are very many types and sizes of locomotives, and railway authorities have agreed upon a simple and useful method of classifying these. The locomotives are named after the arrangement of their wheels, and in these pages we read about the wheels and how they are placed, and can tell at a glance from the picture-diagram on the next page how any particular locomotive is classed

AMONG the most powerful wheels in the world are undoubtedly those of a giant locomotive. They are of great size, are made of steel, and are extraordinarily strong, as they need to be, if they are to support the weight of the big locomotive and also set and keep the train in motion.

While the wheels of a modern locomotive are of great size, they are not now made so large as they were some years ago. At one time it was thought that the larger the wheel the greater the speed that could be attained.

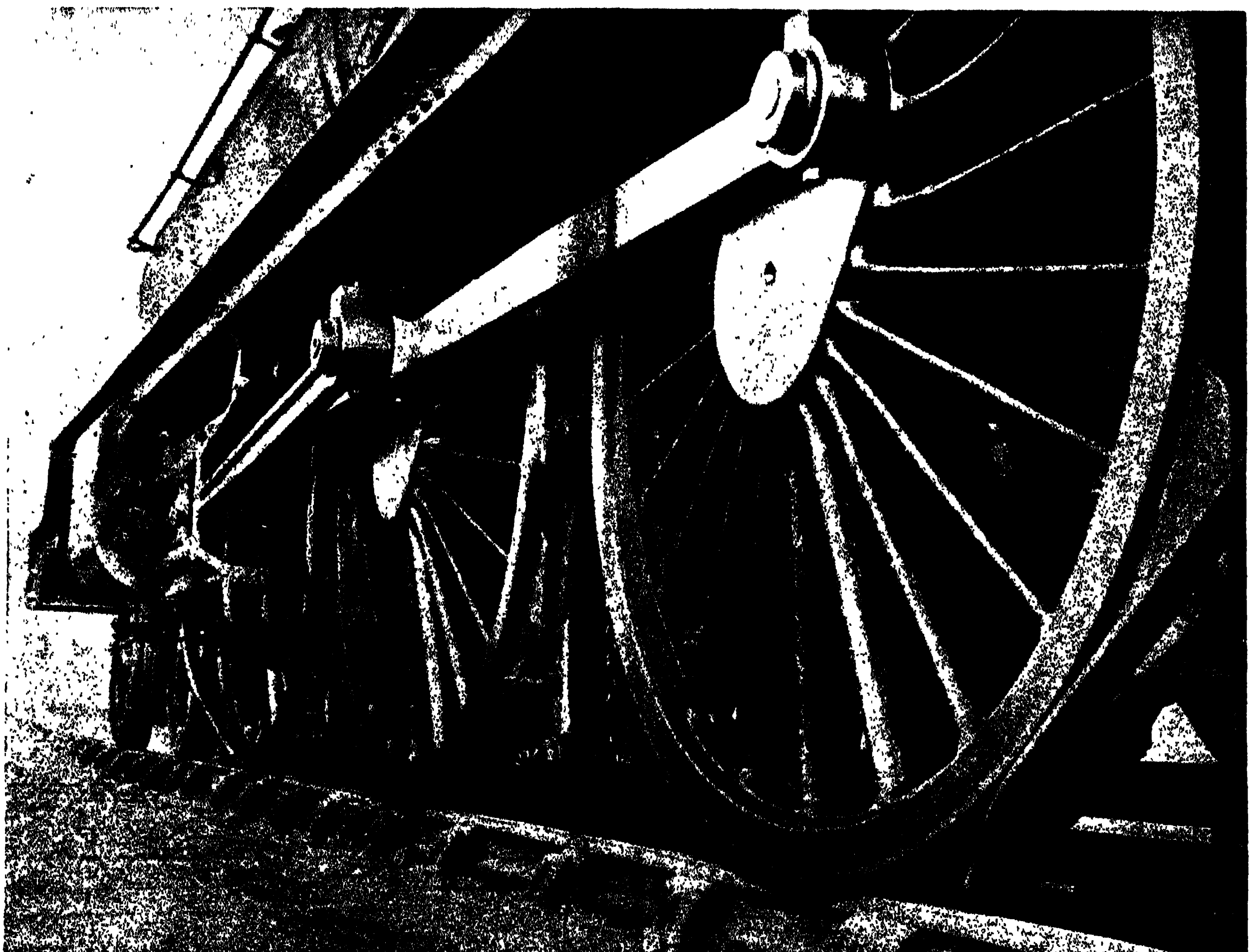
In the early locomotives the piston-rods were connected with one pair of driving wheels only, but as the weight of the locomotives increased it became necessary to couple the large wheels together, so as to get sufficient adhesive weight to make the wheels grip the rails effectively.

Among the early railway engineers who believed that driving wheels of great diameter were necessary if high speeds were to be attained, was Isambard Brunel, the engineer of the old Great Western Railway. He experimented with locomotives which had driving wheels ten feet in diameter, but they did not achieve what had been hoped, for other engines with eight-foot drivers beat them in speed. In the end even Brunel adopted driving wheels with a maximum diameter of eight feet.

Nowadays the coupled wheels of express passenger locomotives which make the vehicle go are from six to seven feet in diameter, though some have wheels over seven feet.

Some years ago a tank engine known as a Decapod, a word meaning "ten feet," was built for the Great Eastern Railway Company, now part of the Eastern Region of British Railways. It had ten coupled wheels all of the same size, and the centre pair had no flanges so as to facilitate the rounding of curves.

Although at the time it was the



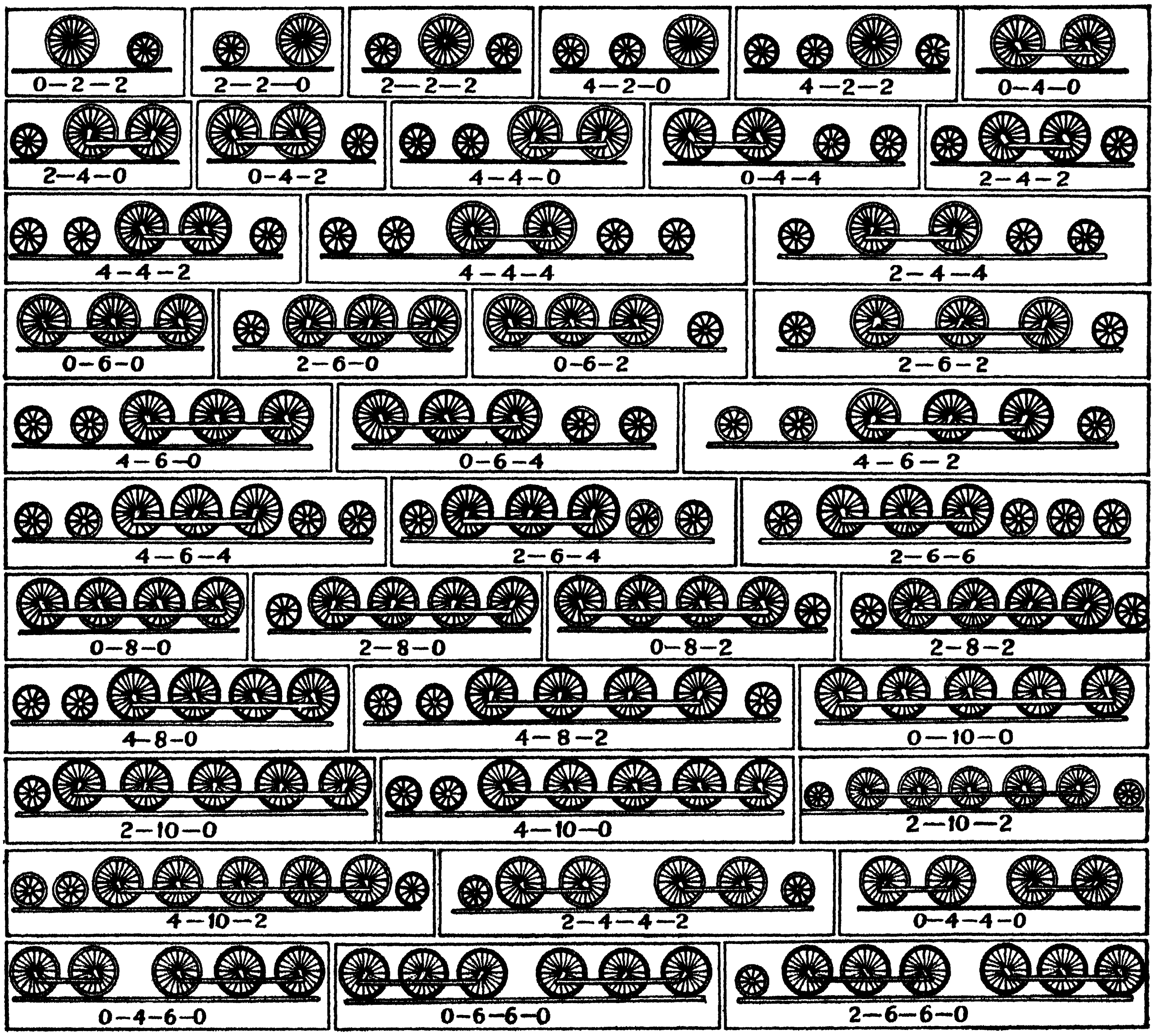
The large coupled wheels of a British Railways Western Region locomotive which draws express passenger trains

most powerful locomotive on the British railways, it weighed only eighty tons. The weight, however, proved too great for the permanent way, especially at some of the weaker bridges, and so it was converted into an eight-coupled engine, with a smaller boiler, and was thenceforward used for goods traffic. Its weight was reduced from eighty tons to fifty-five tons. The coupled wheels of this original Decapod engine were not giants, for they measured only 4½ feet across.

As the length of locomotives became greater some means had to be found of enabling them to go round sharp curves safely, as fixed wheels all along the locomotive could not adjust themselves to the curves and were liable to cause it to jump the rails. To overcome the difficulty a bogie-truck is used, that is, a framework with smaller wheels. This bogie is not fixed rigidly to the main frame of the locomotive, like the coupled wheels, but is connected to it by means of a pin round which the bogie-truck can swivel. Thus it can turn, the wheels adapting themselves to the curve.

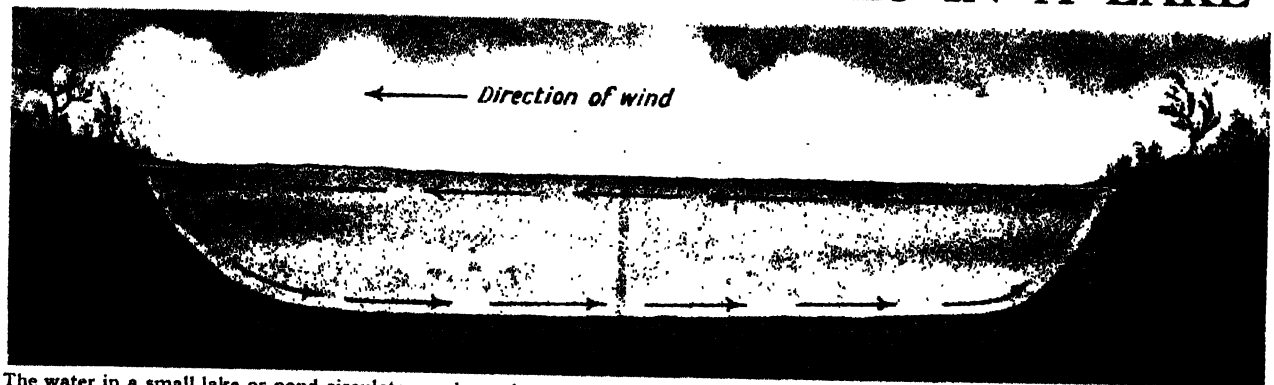
Locomotives are classified according to the arrangement of their wheels. An engine described as 4—4—2 has four small carrying wheels in front, that is, two on each side, four large coupled wheels, that is, two on each side, and two small carrying wheels, one on each side. An engine described as 2—4—4 has two carrying wheels, four large coupled wheels, and four small carrying wheels. If there are no bogies or carrying wheels in front or behind the coupled wheels the fact is represented by a o, thus: 2—6—o means an engine with two carrying wheels and six coupled wheels, while o—6—4 means a locomotive with six coupled wheels in front and four carrying or bogie wheels behind.

Some of these types of engines have special names, such as 2—6—o, Mogul, 4—4—2, Atlantic; 4—6—2, Pacific; 4—6—4, Baltic; 2—10—o, Decapod; 2—8—o, Consolidation; 2—8—2, Mikado; 4—10—o, Mastodon, and 2—10—2, Santa Fé. This wheel arrangement for classifying locomotives can be understood in all languages.

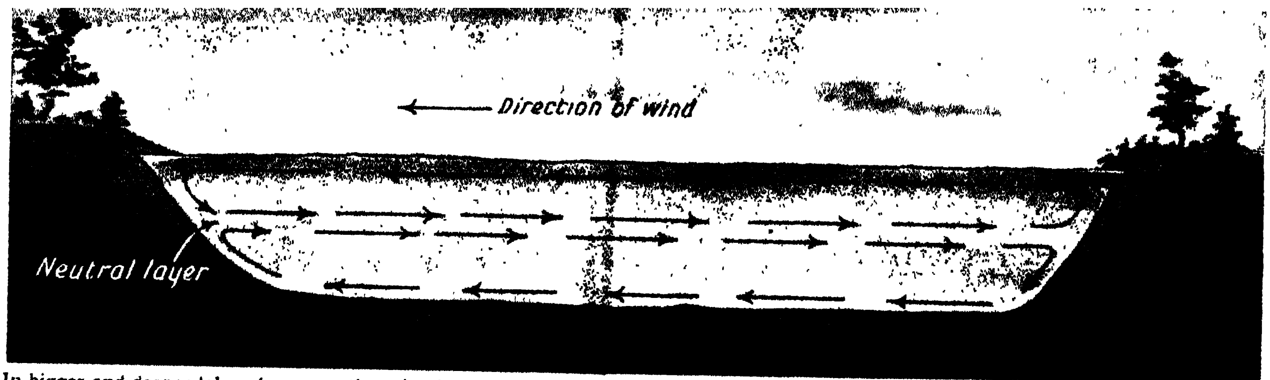


In this picture-diagram we see the many different kinds of wheel arrangements of the world's locomotives. The large wheels that are coupled together can be seen, and if these come in front of the engine, or at the back, with no small wheels outside, in describing the engine o is put to indicate the place where no small wheels are found. Of course, in these pictures we see only one side of the engine, so that if two small wheels are shown, two large ones and two more small ones, there are of course similar wheels on the other side, and the engine is described as 4-4-4. Some of the types of engines have been given specific names, thus: a 2-6-o is called a Mogul type, a 4-4-2 is called an Atlantic type, a 4-6-2 a Pacific type, a 4-6-4 a Baltic type, and a 2-10-o a Decapod

HOW THE WATER CIRCULATES IN A LAKE

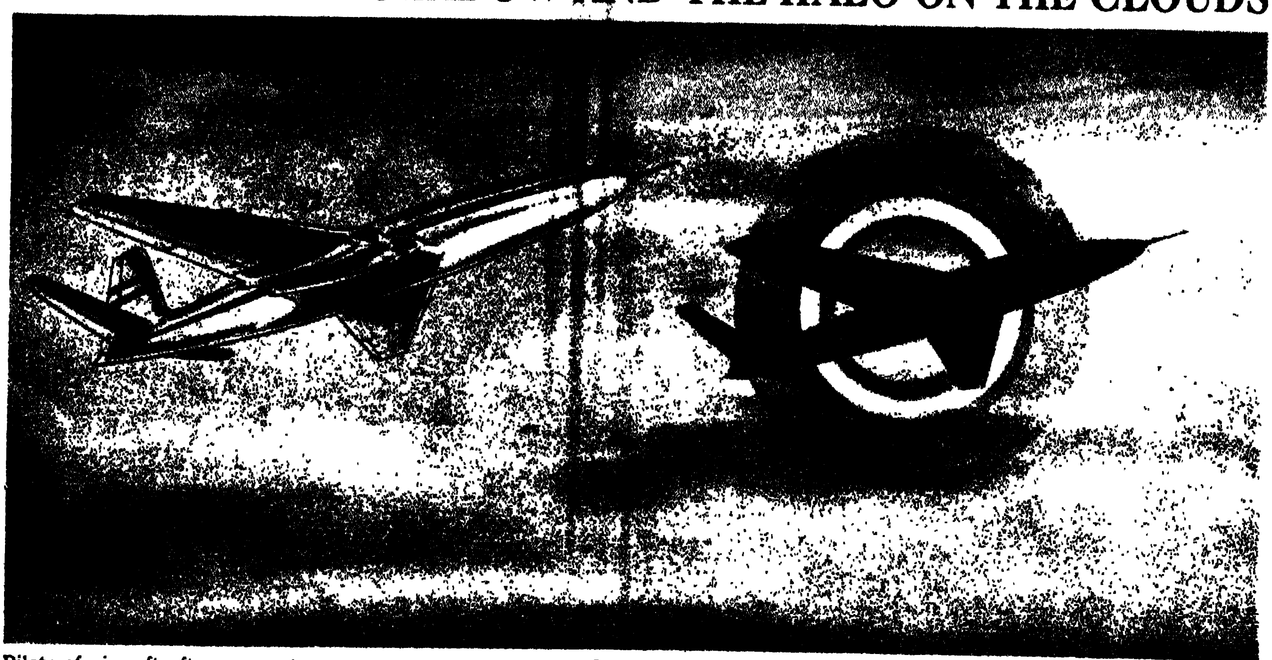


The water in a small lake or pond circulates as shown here and it is kept in movement by the wind. The wind drives the surface water to one side and a return current rises to take the place of the water that has been displaced. The water on the other side then sinks and so there is a regular circulation round and round in the direction of the arrows so long as the wind continues to blow



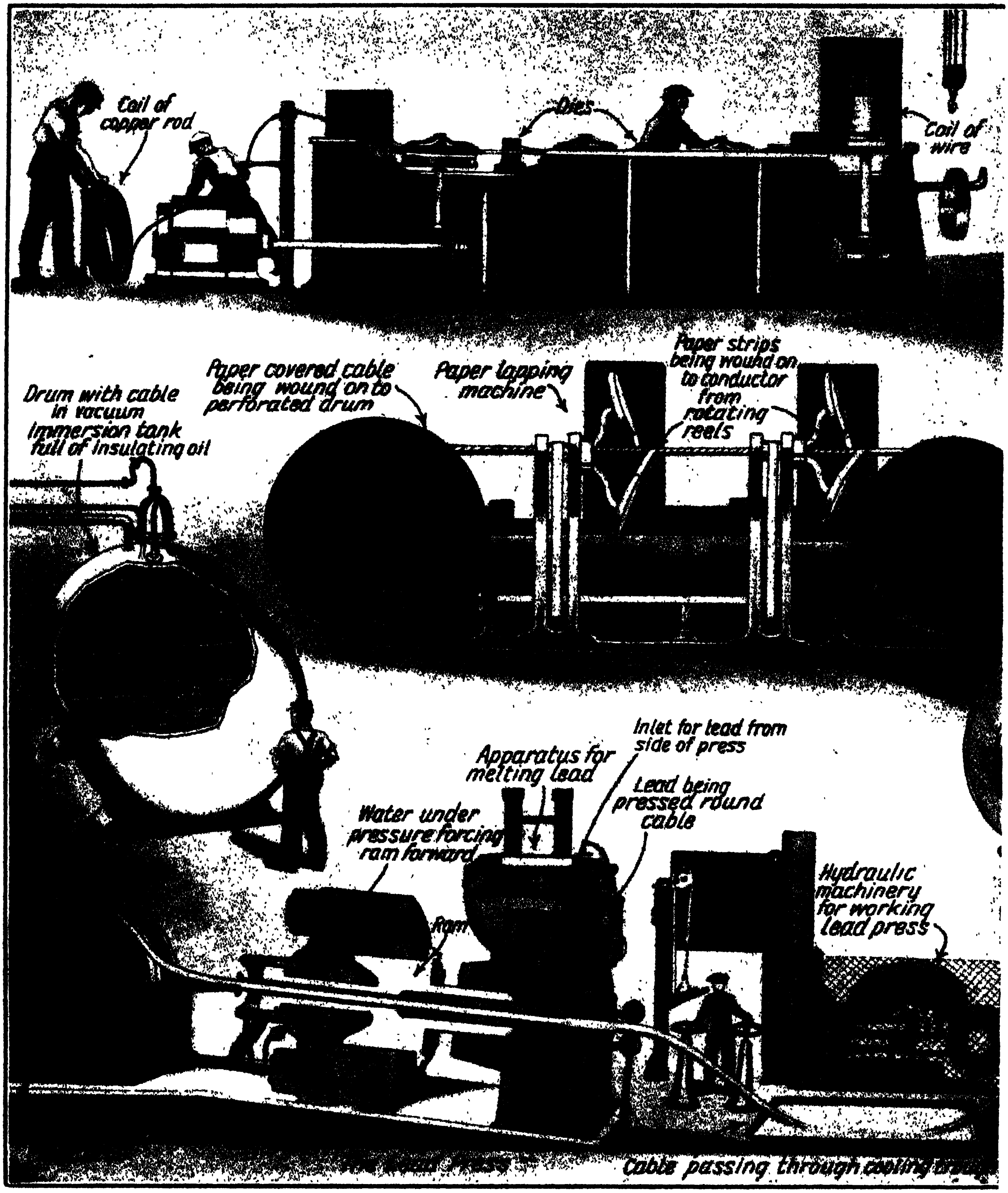
In bigger and deeper lakes, however, there is often a double circulation, as shown here. During the summer the surface water is heated by the sun's rays and becomes so much lighter than the colder water at the bottom that the currents set up by the wind can no longer flow to the bottom of the lake. They therefore have a circulation of their own on top of the colder water. The movement of the upper water, however, causes a current on the surface of the colder water and so there is a second system of circulation near the bottom

AN AIRCRAFT'S SHADOW AND THE HALO ON THE CLOUDS



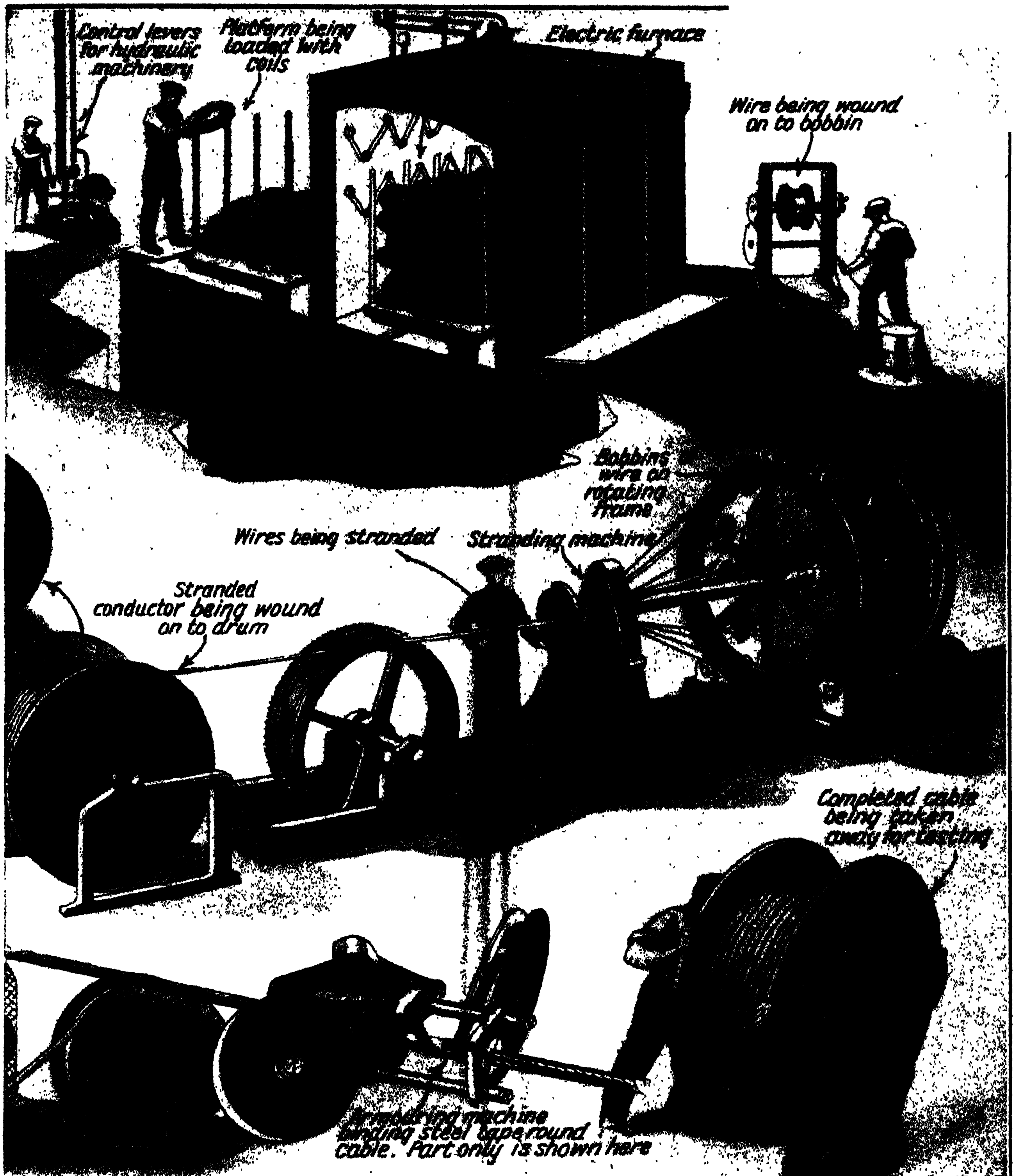
Pilots of aircraft often see a strange appearance in the sky. Projected on the clouds is a shadow of their machine and round the shadow a series of circles, sometimes coloured and sometimes white. This is really the same phenomenon as Ulloa's Circle described on page 171. These circles are due to the refraction or breaking up of the light and its reflection to those travelling in the aircraft

MAKING THE UNDERGROUND CABLES



With the development of the grid system every district in Great Britain will have a supply of electricity. This electricity, generated in a few large power stations, is carried all over the country and into the towns by overhead wires strung on tall steel towers, and by underground cables. Hundreds of thousands of miles of wire are used for this purpose, and the making of the wires and cables is a very big industry involving great technical skill. On these two pages we see the many complicated and highly mechanical processes in the making of an underground cable at W. T. Henley's Telegraph Works Company, Ltd., at Gravesend. Of course, the machinery is here shown greatly simplified. Coils of copper rod are drawn through dies to reduce the diameter. There are nine of these dies on a machine, but only three are shown. The wire gets smaller as it goes through the dies, and at the end it is wound on to a reel. This coil of wire is lifted off and annealed or softened in an electric furnace. The furnace is water-sealed at the bottom ; it runs to and fro on wheels which are under water. Two platforms bearing the coils of wire travel up and down by hydraulic power. The one on the left outside the furnace is being loaded, while the one on the right is in the furnace. As soon as the platform outside is loaded, both platforms will be lowered, the furnace will then be moved to the left, and the platforms will rise, the one on the left then being in the furnace, and the other outside with the annealed coils ready for unloading. The wire of each annealed coil is then wound on to a bobbin which is put with others on a circular frame on a stranding machine. This frame rotates and as it does so the wires are drawn through an opening and wound together into a stranded conductor. This goes twice round a revolving drum and then is wound on to a wooden drum which when full is rolled to a

THAT CONDUCT THE ELECTRICITY



paper-lapping machine, which wraps it with a number of layers of insulating paper. The paper is in large coils, arranged in pairs. Although there are about a dozen pairs on the machine, only two pairs are shown here. The coils of paper known as paper-lappers are rotated by pulley and belt, and as they revolve the paper is wound round the conductor, which is travelling forward all the time, and when it has received the necessary number of wrappings it is wound on to a perforated drum. The drum when full is immersed in insulating oil in a vacuum immersion tank. The oil is hot, and reaches every part of the cable owing to the perforations in the drum, and to the fact that the cable is in a vacuum. After immersion, the cable passes to a lead press, where it is given an outside sheathing of lead. It is fed into the press, where a powerful ram, shown white in the drawing, forces the lead, indicated as a dotted mass, round the cable as it passes through. At the back is shown the lead-melting apparatus and the hydraulic machinery. The lead is melted to run into the lead chamber, but solidifies before being forced into a tube round the core by tremendous hydraulic pressure. The lead-covered cable as it comes out is cooled in a bath of water, and then passes to an armouring machine similar to the paper-lapping machine, but this time the wrapping is steel tape. Sometimes the cables are armoured with steel wires. The whole machine is not shown, but only a close-up view of the steel tape being wrapped round the cable. The cable is then wrapped with tarred yarn, which is afterwards whitewashed to prevent the layers sticking to one another. It is then wound on to a drum and rolled away for testing. When it has passed the test it is ready for use, and we may often see the men at work in the streets putting these electric cables underground through manholes, and direct into trenches

A VAST FOREST LAID LOW IN A MOMENT

This photograph, taken in Siberia by Professor Leonide Kulik of the Russian Academy of Sciences, shows one of the most amazing scenes to be witnessed anywhere in the world. We read on page 523 of a huge meteorite which flashed through the air and struck the Earth about five hundred miles north of Irkutsk on the night of June 30th, 1908. It completely devastated an area of a hundred square miles, and in addition left a crater-like depression as big as Kent and Essex together. The terrific heat due to friction with the atmosphere expanded the gases inside the meteor and made it explode into many fragments. Outside the devastated area the compressed air due to the rush of the meteorite laid low the forest all round. Thousands of tall trees, as can be seen in the photograph above, were hurled over in a moment as though some giant hand had just been swept across them, pushing them all down together. Nothing like it, on so gigantic a scale, has ever been seen before. It is a disquieting thought that if the meteorite had struck the Earth a little later, when our globe had turned round on its axis towards the rising sun a little more, this terrible messenger from space might have struck London. Had it done so, there would have been no London now. The whole of the world's greatest city with its inhabitants would have been wiped out in a moment. The photograph is given here by the courtesy of the American Weekly, New York, whose copyright it is

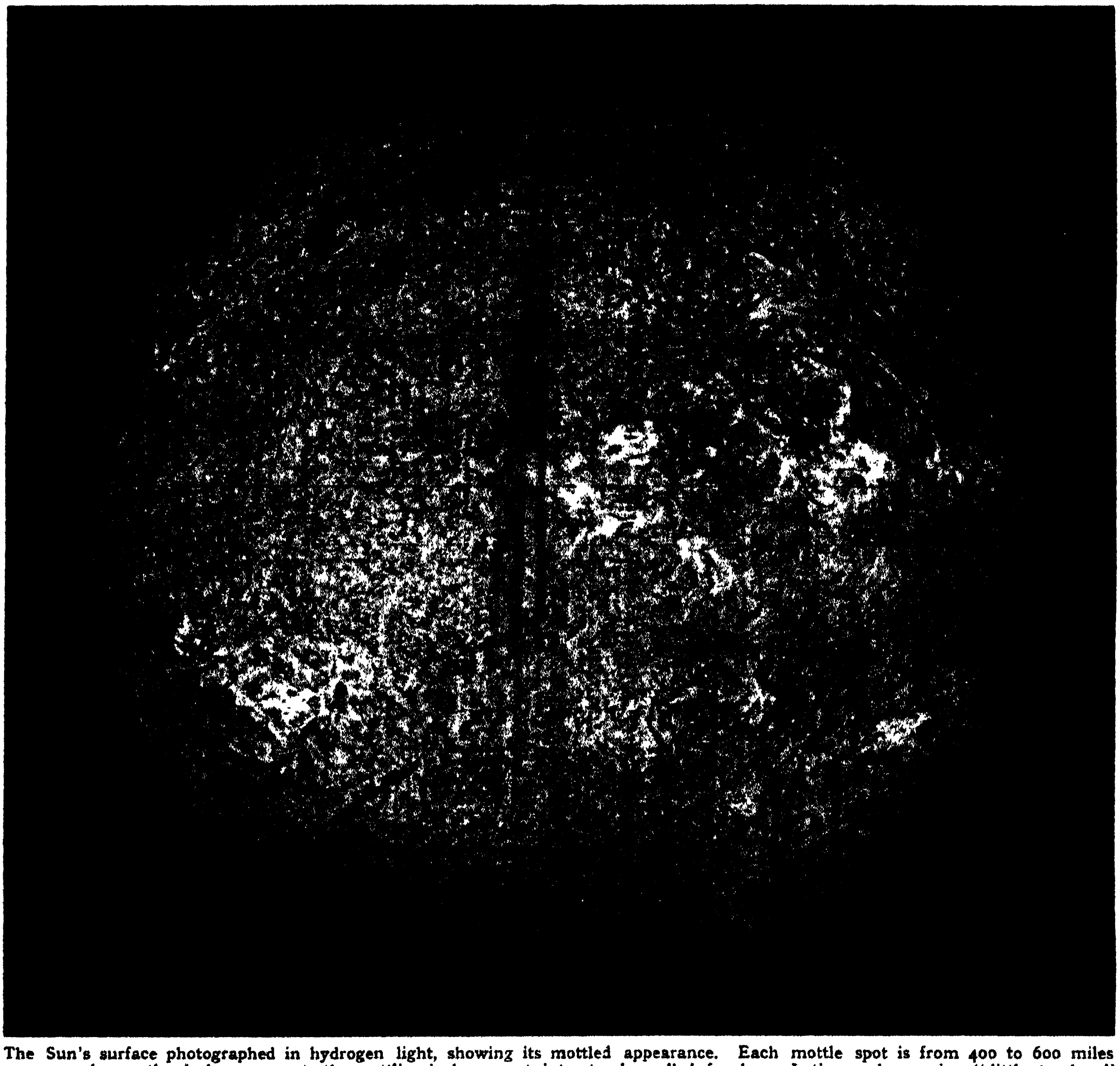
SOME SECRETS OF THE SUN AND STARS

While powerful telescopes have revealed to us the appearance of the Sun's disc with its tempests and prominences or huge flames, it is the spectroscope, as we read here, that has explained the true nature of these things

We should know very little indeed about the Sun were it not for that most marvellous of all instruments, the spectroscope, of which we read on pages 450 to 452 of this book. By its aid men of science have discovered that in the Sun's atmosphere, that is the gaseous envelope that surrounds it and which is cooler than its intensely hot core, there are about forty of the elements that exist on the Earth. This shows us that the various bodies of the solar system must have had a common origin, as they are actually made of the same materials.

The chief difference between the elements as they exist on the Earth and as they are found by the spectroscope in the Sun, is that on the Earth they are mostly in the form of chemical compounds, while in the Sun and also in the stars they are, with very few exceptions, uncombined and exist as gases at enormously high temperatures. Even iron is found as a gas in the Sun.

Most of the elements discovered in the Sun's envelope are metals, but there



The Sun's surface photographed in hydrogen light, showing its mottled appearance. Each mottle spot is from 400 to 600 miles across, and near the darker sun-spots the mottling is drawn out into streaks called faculæ, a Latin word meaning "little torches." This photograph is given by courtesy of Mount Wilson Observatory, U.S.A.

are also hydrogen, helium, oxygen and carbon in certain compounds The heavier elements, like gold and quicksilver, have not yet been discovered, but they are probably there. Owing to their heavier nature, no doubt they lie deep down in the Sun's body

It is the dark lines appearing in a solar spectrum, as described on page 452, which tell us what elements exist in that distant luminary But the work of identifying these lines and comparing them with the spectrum given by the artificial light of an element on the Earth, is very long and tedious.

A Difficult Task

Already no fewer than 14,000 dark lines have been mapped out on the solar spectrum. At least one-third of these lines is found to be due to the absorption of the Sun's rays by gases in the Earth's atmosphere Some of the lines in the solar spectrum are very faint, and the work of identifying them is exceedingly difficult. Something like 6,000 of the lines have yet to be determined with certainty.

The motion of the Sun causes a shifting of the lines in the spectrum, and from that fact we can work out the time the Sun takes to turn on its axis, thereby checking the calculation of the rotation from watching the passage of sun-spots across its disc

It is because of this shifting of the dark lines on the spectrum that we are able to pick out the lines which are due to the Earth's atmosphere and thus identify those which originate only in the Sun By watching the dark lines of the spectrum, too, we are often able to detect storms on the Sun's surface, for when there is a great upheaval or outburst of activity, the dark lines become distorted.

Helium Discovered

It is by means of the spectroscope that we know so much about the Sun's prominences, those vast flames which can be seen only during a total eclipse. Their spectrum shows them to be composed of hydrogen gas, and a mysterious yellow line which appeared in the spectrum was at first thought to be due to sodium. Then it was realised that this must indicate another element which was not known, and the element was called helium. That was in 1868, and in 1895 Sir William Ramsay discovered helium on the Earth.

The Sun's surface is photographed in various lights, such as that of hydrogen gas, calcium, and so on, and each kind of photograph reveals some new features of the surface. The photograph on page 843 was taken in hydrogen light, and it shows clearly the mottled appearance of the Sun's disc, which is described by different astronomers variously as the "rice grains," "nodules" and "snowflakes." Each mottle spot is from 400 to 600 miles across, and near the darker sun-spots they are drawn out into streaks often thousands of miles long These are sometimes called "filaments," sometimes "willow leaves," and sometimes "faculæ," a Latin word meaning "little torches."

The faculæ are believed to be clouds floating in a less luminous atmosphere, just as clouds on the Earth float in our air. They are intensely bright, for the same reason that a gas mantle is brighter than the gas flame that heats it. If all the Sun's surface were as bright as these faculæ its brilliance would be increased tenfold.

Some Astonishing Facts

To read an account of the Sun which embodies all the most recent discoveries of the astronomers by means of the spectroscope, may well cause astonishment, for it is almost as minute and detailed as if the astronomers had actually been able to go to the Sun and examine its surface at close quarters.

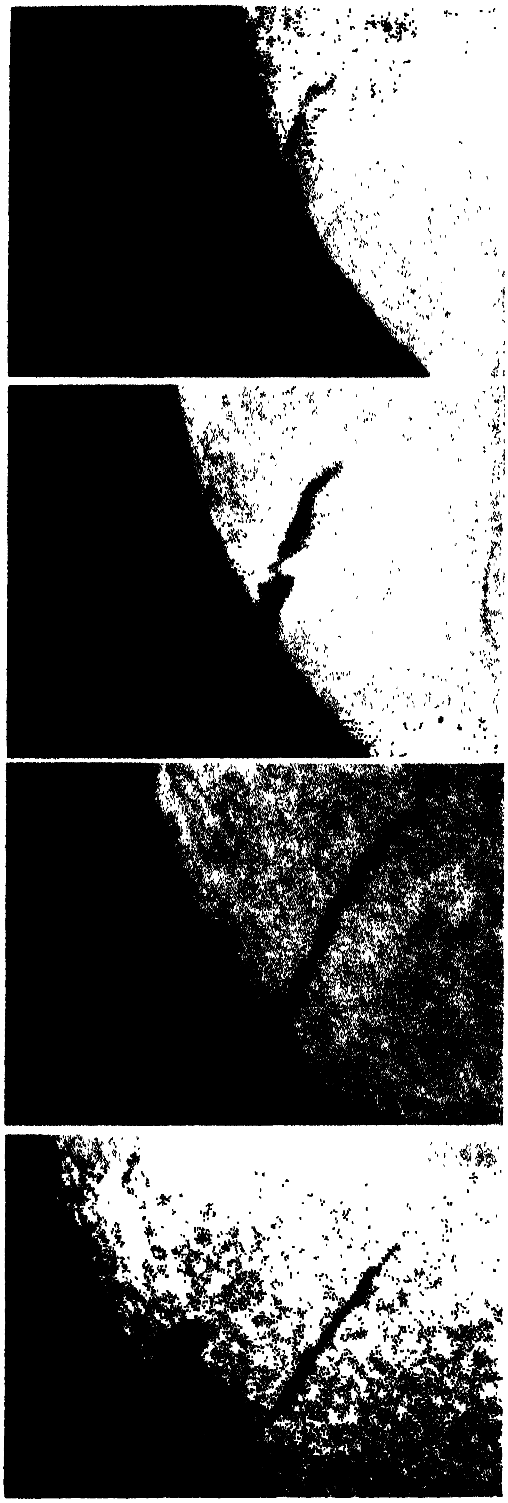
They not only tell us the substances found there, but how they are behaving, how far the flames shoot up from the surface, how the glowing hydrogen is sucked down into the lower depths, and how the sun-spots show magnetic effects as the result of the whirling electrons.

They also tell us as a result of their spectroscopic studies, that there must be free electrons in the Sun which have become detached from atoms, together with scores of other facts which are chiefly of interest to scientists.

What is true of the Sun is equally true of the stars. No longer can these points of light which flash to us from a distance of millions of millions of miles shroud their nature in mystery. The spectroscope reveals them, just as it reveals our own Sun.

A Marvellous Instrument

By means of the spectroscope the stars are divided up into various classes, and the spectra obtained give us a great deal of information about their temperatures and their motions. We can tell, for instance, by watching the lines of a star's spectrum, whether the star is approaching or receding from the Earth. The principle on which this depends is illustrated by the case of a locomotive passing us at full speed and whistling as it passes. The pitch of the note is higher as the engine is approaching than after it has passed. The pitch depends on the number of sound-beats per second that reach us and in a similar way the beats of the light-waves are closer together when their source is moving towards us than when it is at rest or moving away. There is no knowing what wonders may yet be revealed by this marvellous instrument.



A remarkable series of photographs given by courtesy of the Royal Astronomical Society, showing the passage on to the Sun's disc of a solar prominence, a vast flame shot up for tens of thousands of miles. The photographs were taken on four successive days in August, 1929

PLANTS THAT GIVE OFF TONS OF WATER

The vital need of water to all life is as clearly shown in the history of a plant as in that of an animal. Without water no creature can live, although in many cases it is possible to go on for a long time without food. Water must constantly pass through every part of the body of an animal and plant if it is to live and thrive. Here we read something about the wonder of water so far as it concerns plant life

LIKE human beings and all animals, plants need a constant supply of water if they are to live and thrive. This water they absorb through their roots, which they will often send down to a surprising distance in the search for water.

Plants are made up largely of water. In some of them which live in ponds and streams, as much as 99 per cent. of their weight may consist of water. Plants which live on land, and even those in dry, arid districts like the deserts of America, have more than half their substance made up of water. The grass of our meadows and lawns consists of four-fifths water and one-fifth dry matter.

But apart from the water of which the plants' substance is composed, there is a constant stream of water rising from the roots up the stem and passing off into the air through openings in the leaves. These leafy openings are known as stomata, and one leaf of an oak tree may have as many as two million openings in it. As the water passes through the plant it not only keeps the whole structure fresh but it supplies water to the cells.

Water from Earth to Air

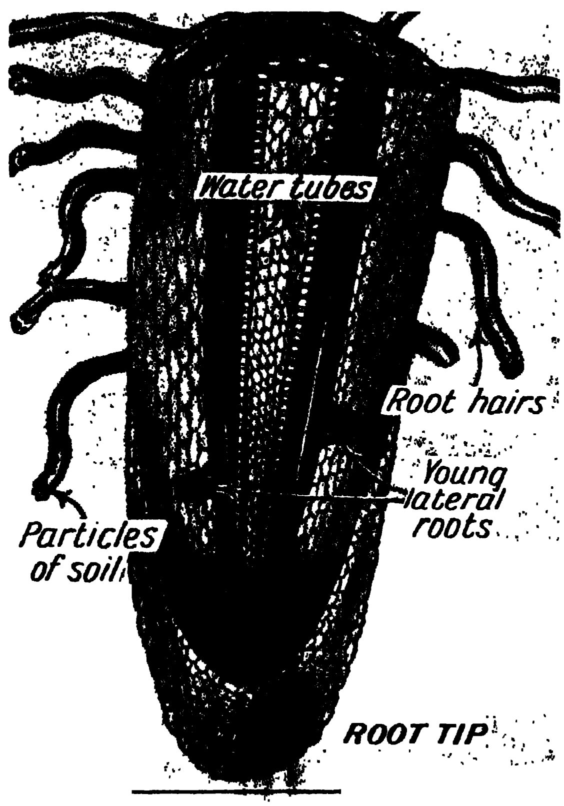
The amount of water which a plant thus takes up through the roots and passes off into the air is astonishing. Grasses have been known in fine, dry weather, to take in their weight of water once in every twenty-four hours. When the water reaches the leaves it is passed off into the air, and experiments have shown that a birch tree with 200,000 leaves standing in open ground, gave off on every hot summer day 700 to 900 pounds of water. At other times, when the weather was dull and the air full of moisture, the tree transpired probably not more than 20 pounds of water. A single oak tree with 700,000 leaves is estimated to have given off into the atmosphere in five months, 230,000 pounds of water, or over a hundred tons.

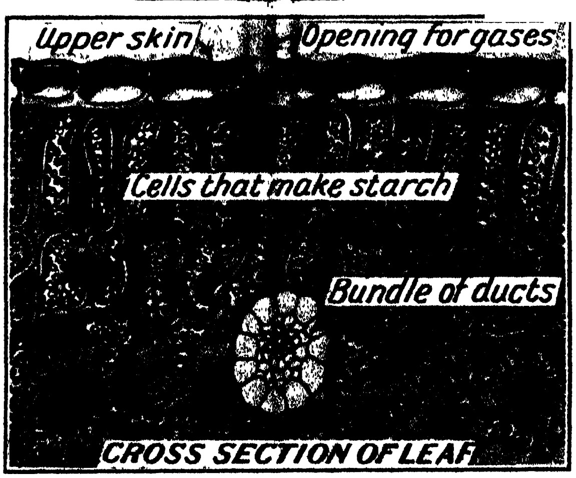
An oak tree may live for a thousand years, and during that time it is calculated that it will have given off something like a quarter of a million tons of water. How much water must have been given off by the giant redwood trees of America, some of which are 3,000 years old, it passes the imagination to conceive.

Another calculation by scientists shows that in four months an acre of cabbages will give out through their leaves $3\frac{1}{2}$ million pints of water, and an acre of hops from 5 to 7 million pints. A sunflower plant that was tested was found to pass off into the air in 140 days no less than 145 pounds of water.

When one realises the number of plants in the world and the myriads that have been growing through the ages, it is safe to say that oceans of water have been taken up by the roots and breathed out by the leaves.

The absorption of water by the root usually takes place through the root hairs. These have very thin walls, but even under the most powerful microscope show no holes or pores, yet the water penetrates very rapidly to the inside of the root hairs. The number of these hairs on some plants is enormous. In the common pea every hundredth of a square inch of root surface has nearly 1,500 hairs.





The upper picture shows a section through the end of a root greatly enlarged. It is through the root that the plant takes up water, and this passes to the leaves through little tubes, as shown. The lower picture shows a magnified section through a leaf. Water passes through tubes in the bundle of ducts, and chlorophyll, a green colouring matter, in the cells, makes food for the plant out of the water and carbon-dioxide gas, which the plant takes in

In Search of Moisture

If the root cannot find water it goes out in search of it, and will sometimes grow to many times the size of the plant appearing above ground. The mesquite of Mexico, when appearing as a shrub two or three feet high, in dry soil, will often have a root that extends down to a depth of 60 feet or more. In fact, the Mexican farmers, when digging wells, usually follow these roots as guides, for they almost invariably lead to water.

It is from the water taken up by the roots and from the carbon-dioxide gas taken in through the little mouths or stomata in the upper skin of the leaves that the plant is able to make the starch and other food substances for its growth.

The leaf of a plant is really a factory for the production of food, and it is by means of the green colouring matter in the leaf known as chlorophyll that the water and carbon-dioxide are changed into food.

Water, as we know, consists of a combination of oxygen and hydrogen, and carbon-dioxide is a combination of carbon and oxygen. The changes that are brought about by the chlorophyll under the action of the Sun rearranges the atoms of carbon and hydrogen and oxygen, so as to form the new substance starch which contains all three chemical elements.

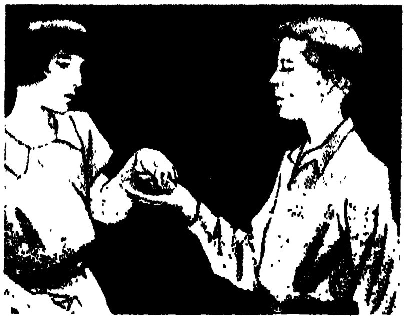
The chlorophyll of plants needs sunshine for its development, for if a plant is grown in a dark place it has no green colour, but becomes pale and almost white. We see this in the case of celery when it is earthed up so that the sunlight cannot get to the stems.

Exactly what the chemical composition of chlorophyll is, no one can say definitely,. It decomposes so rapidly when it is extracted from the plants that it cannot be properly analysed. When it decomposes it changes into two independent coloured substances, one a golden-yellow, and the other a blue-green. But chlorophyll itself is a single pigment; these two substances are the product of decomposition.

Some attempt to show the wonderful operations that go on inside the substance of a leaf has been made in the full-page picture on page 847. It will be seen that plants are no more able to live without water than are animals. In fact, we all live in a stream of water which passes in and out of our bodies.

EXPERIMENTS TO TEST OUR SENSE OF TOUCH

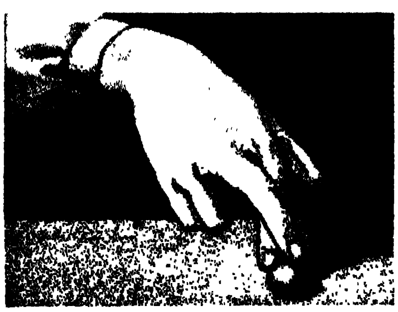
The sense of touch is a curious thing, and the touch nerves vary very much in number in different parts of our bodies. We have already seen on page 431 a number of interesting experiments which we can carry out in connection with touch. Here are some more of these experiments.



Judging the size of an object by touch

If we wish to judge with reasonable accuracy of the size of an object by means of touch we must move our fingers over it. Close your eyes, hold out your open hand and ask a friend to place some object such as a piece of wood or a small bottle in the palm. Now try to estimate the size of this object. You will be surprised when you open your eyes to find how you have misjudged the matter. Yet with your eyes shut, if you put your fingers over the object you can get a very accurate idea of its size.

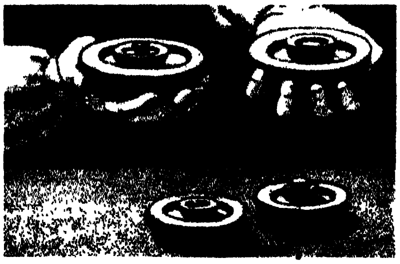
Another example of how our sense of touch sometimes deceives us is shown in the second picture here. Take a small sphere, such as a marble, and crossing the first two fingers place them on the sphere, closing your eyes. You will fancy that you are touching two balls and not one.



The one marble that feels like two

An interesting experiment in which the muscular sense as well as the sense of touch is brought into play can be carried out to estimate the difference between two weights. We shall find that if we hold in each of our hands a light weight we shall be able to detect even a slight difference between the two weights. But if we replace those weights with two heavy weights, it will not be possible to detect, with the same difference between the two, which is the heavier.

For example, if we hold in one hand a weight of 20 ounces and in the other 21 ounces, we can clearly detect the difference. But if we now use weights of 40 and 41 ounces, it will be impossible to tell which is the heavier. The heavier the weights the larger must be the difference between them to be detected by our two hands.



Testing slight differences in weight

The back is far less sensitive to touch than, say, our forefinger or lip or tongue. Ask a friend to touch your back with two fingers wide apart. You will find that you get the sensation of being touched by only one finger whereas, as we have seen by the experiments with the compasses on page 431, it is easy on the tongue or lip or forefinger or nose to detect the two points when they are very close together.

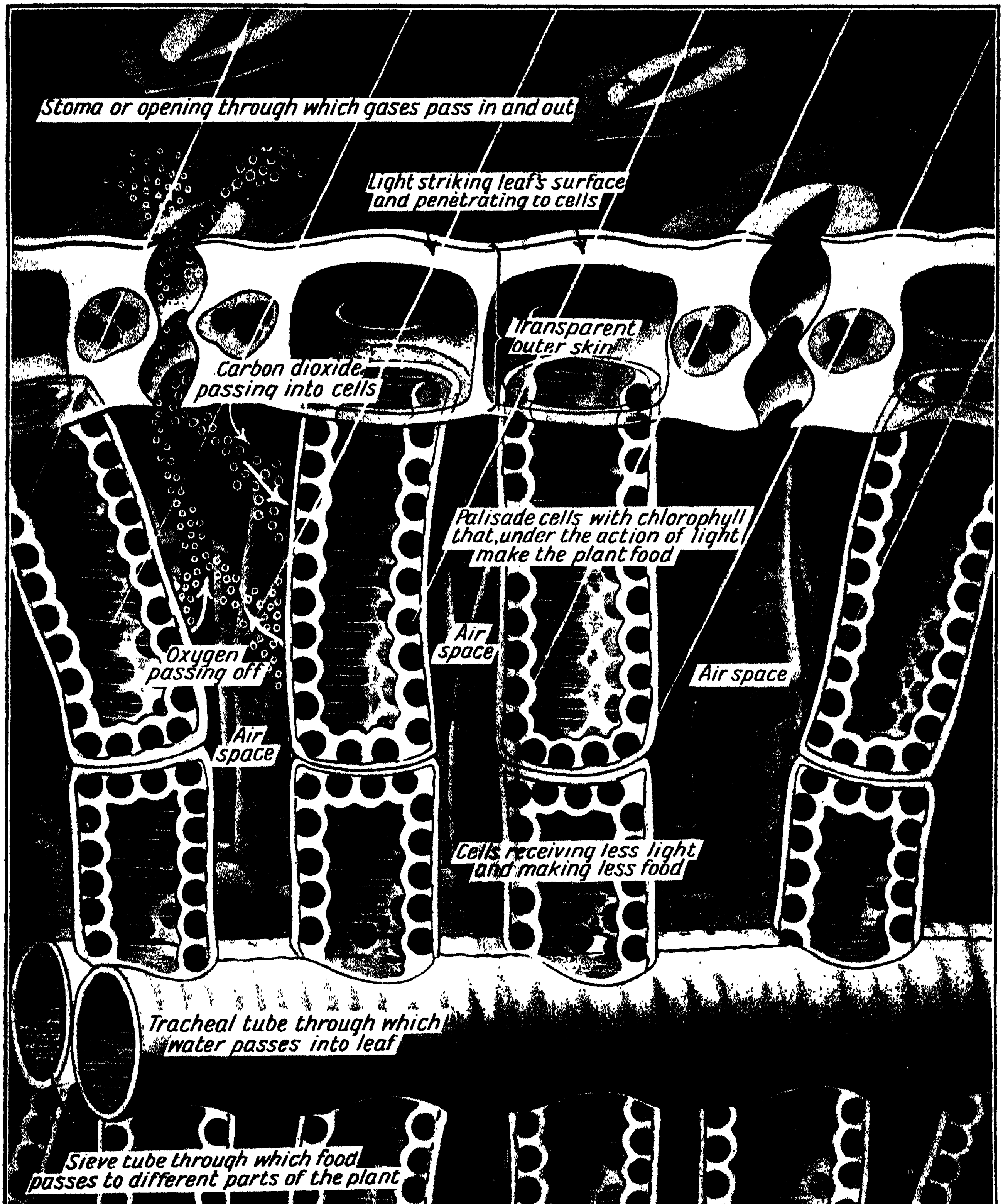
Many interesting experiments can be carried out in connection with the sensations of heat and cold. The temperature of our skin varies a great deal because we are constantly gaining or losing heat. The gain, of course, depends on the amount of warm blood flowing through the skin. The loss of heat occurs when our skin is exposed to the air, especially on a cold day. The skin temperature may vary between 97 degrees Fahrenheit and 90 degrees. This means that on a cold day, when our skin is at about 90 degrees, any object of a higher temperature would feel warm, while on a hot summer day, when our skin temperature is 97 degrees, anything cooler than that would feel cold.

An experiment in touching the back

Here is an interesting experiment which we can carry out. Have three basins of water, one quite hot, one quite cold and one lukewarm. Place one hand in the hot water and keep it there for a few moments, and the other hand in the cold water. Then take the hands out and plunge both into the lukewarm water. The hand that has been in the hot water will find the lukewarm water cold, while the hand that has been in the cold water will find the lukewarm water hot.

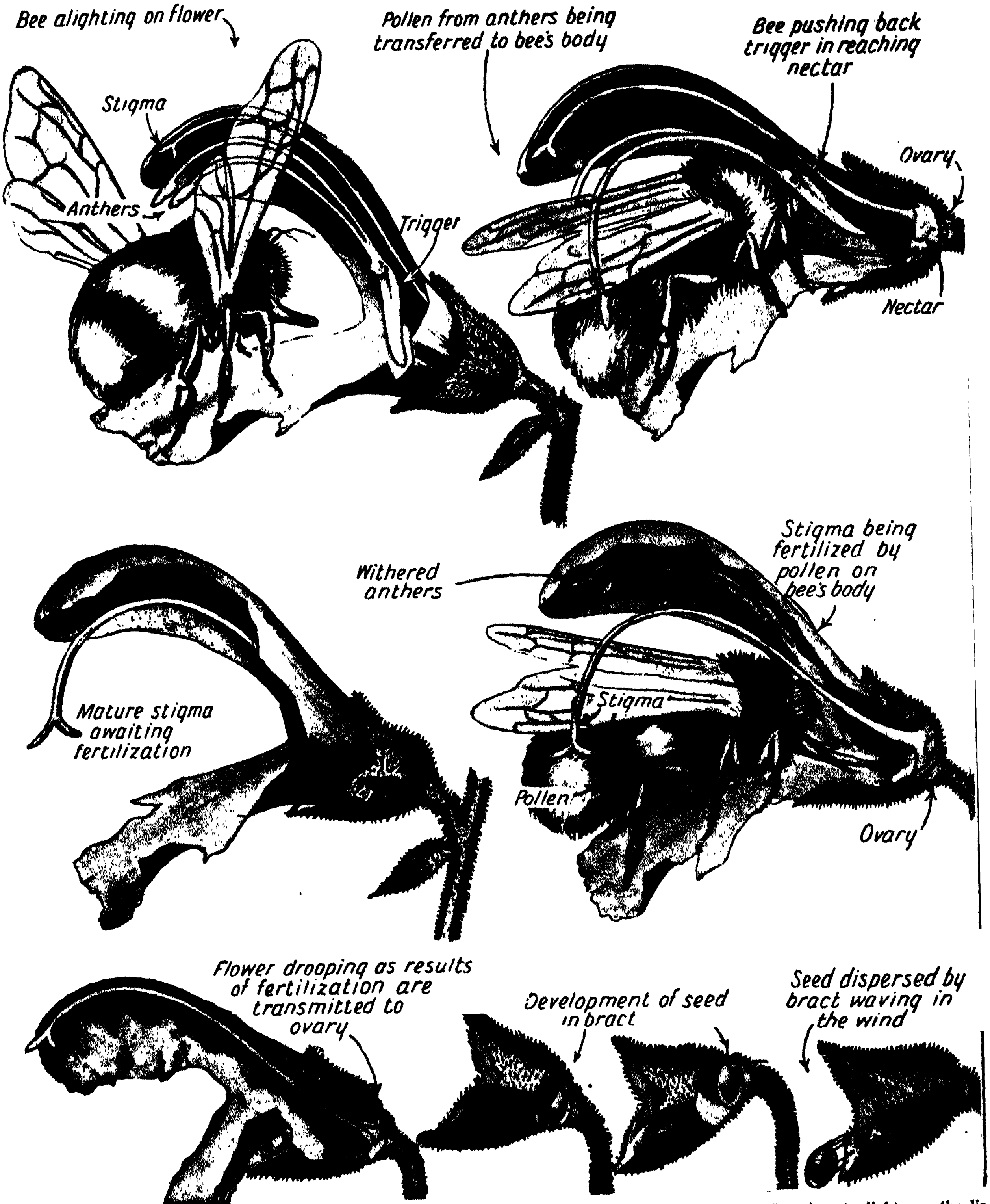
Touch tests with heat and cold

THE WORK THAT GOES ON INSIDE A LEAF



This picture shows in diagram form the inside of a leaf, of course enormously magnified. It is in the leaves that a plant makes tne food which will nourish it and help it to grow. In other words, the leaf is really a factory. Inside the leaf under the outer skin are a number of cells containing a green substance called chlorophyll. When the Sun's light shines upon the leaf it penetrates the outer skin, which is more or less transparent, and acting upon the chlorophyll, enables it to make starch and other food materials out of the water taken up by the roots and the carbon-dioxide gas breathed in through little openings in the skin called stomata. "Stomata" is the plural of the word "stoma," which is the Greek name for a mouth. If these mouths are closed up the plant cannot obtain carbon-dioxide from the air, starch cannot be produced, and the plant dies. The water passes all over the leaf through little tubes, and the food when it is made is also distributed to the plant through tubes. Oxygen gas is given off by the plant, and passes into the air through the stomata

THE ROMANCE OF A BEE AND A BLOSSOM



These pictures show how a British wild plant, the meadow sage or meadow clary, is fertilised by the bee. The insect alights on the lip of the flower in search of nectar, which is secreted at the base of the blossom. Two anthers, which are part of the male portion of the flower, containing the pollen, are attached to an arm, which acts as a lever or trigger. The bee, pushing its way in, moves the lever, bringing the ripe anthers on to its back, where a load of pollen is deposited. The anthers, having done their work, soon wither. The bee with the pollen flies to another blossom, in which the mature stigma or female portion of the flower is waiting to be fertilised. As the bee goes into the flower it brushes past the stigma, which catches some of the pollen and is fertilised. The ovule, or egg, in the ovary at the foot of the stamen, being fertilised, develops into a seed, which when ripe is thrown out to produce a new plant

THE MOST DANGEROUS OF THE BIG CATS

Of all the big cats the leopard or panther is the most widely distributed. Its area is becoming more and more restricted, but in the old days it was found all over Africa and throughout Asia. Earlier still it was found in Europe, as we know from the fossil bones which are dug up from time to time in England and elsewhere. Here are many interesting facts about this fierce and dangerous animal

THE leopard is a very close relation of the lion and tiger, from which it is distinguished chiefly by its spotted coat and smaller size. There are many kinds of leopards, varying greatly in size, and the term "leopard" is generally used of the smaller species, while the larger are referred to as "panthers." But the variations in size are so gradual that it is quite impossible to say where leopards end and panthers begin.

In India the leopard is generally called the panther, while the term "leopard" is there restricted to the cheetah, or hunting leopard, which really belongs to quite a different genus of animals. Distinctions in the name, however, are popular rather than scientific.

The smallest leopards are about five feet long from the snout to the end of the tail, while in the larger species the length is often eight feet. The biggest specimens known have come from Eastern Siberia. Generally, the tail is about as long as the body.

In colour, as well as in size, the leopards vary greatly. Generally, the ground colour of the skin is yellowish fawn, but in many specimens this becomes a rich nut-brown, or it may be so light that it is almost white. The spots, which vary in size and number, are in the form of rosettes, consisting of an irregular black ring, more or less incomplete, enclosing a light central area On the head, flanks and lower part of the limbs the spots are brown, rather than black, and have no light centre. In Indian leopards the rosettes are rather larger than those of the African beasts.

Both in Africa and Asia, leopards nearly black, in which the spots almost disappear, are found ; they are said to be fiercer than normal leopards. Still rarer are leopards that are almost white

More Dangerous Than a Tiger

The leopard is a more agile animal than either the lion or the tiger It is much more sly and stealthy, and is, if anything fiercer than its relatives. Both Europeans and natives describe it as a more dangerous animal than either the lion or the tiger, as it can be roused to fury by less provocation and is very vindictive. When wounded a leopard will charge, even if many rifles are turned upon it.

It lurks among the rocky hills covered with scrub, under overhanging masses of rock, in thickets and among the tall grass, and in ravines and gulleys. From such haunts it watches the country, and when it sees suitable prey descends upon it with remarkable speed and stealth.

Its food consists of the smaller wild animals, such as antelopes, deer, forest pigs, monkeys and birds ; but it loves to lurk in the neighbourhood of man's habitation, so as to prey upon the cattle, ponies, sheep, donkeys, goats and dogs It is particularly partial to dogs, and often in broad daylight will swoop down and carry off a pet dog before the eyes of its European master.

On one occasion Sir Samuel Baker was walking in Ceylon with a powerful bull terrier, the dog running within a few yards of him, when suddenly it disappeared as if by magic. It was later discovered that it had been carried off by a leopard, but the animal had not been seen There was no suspicion of its nearness, and the dog's death was instantaneous, so it did not utter even a single cry.

The leopard often buries a part of its victim's carcass, and in Africa frequently puts the remains in the branches of a tree ; for it differs from its relatives, the lion and tiger, by being thoroughly at home in a tree. It can run up a straight-stemmed, smooth-barked trunk almost as rapidly as a monkey, and it can take tremendous leaps in proportion to its size

At night it will visit a village and climb over the walls into the folds and pens for goats and calves. It is very patient and persistent, and if the walls are high and strong, the leopard will walk round and round them for hours

Leopards, like their relations the domestic cats, often play together, but at other times they snarl and quarrel. In this photograph two leopards at the London Zoo have been having a game, which has developed into something like a quarrel

trying to find an entrance. But it is also very daring, for it will wait for the domestic animals to be driven in for the night, and then seize a straggler under the very eyes of the herdsman.

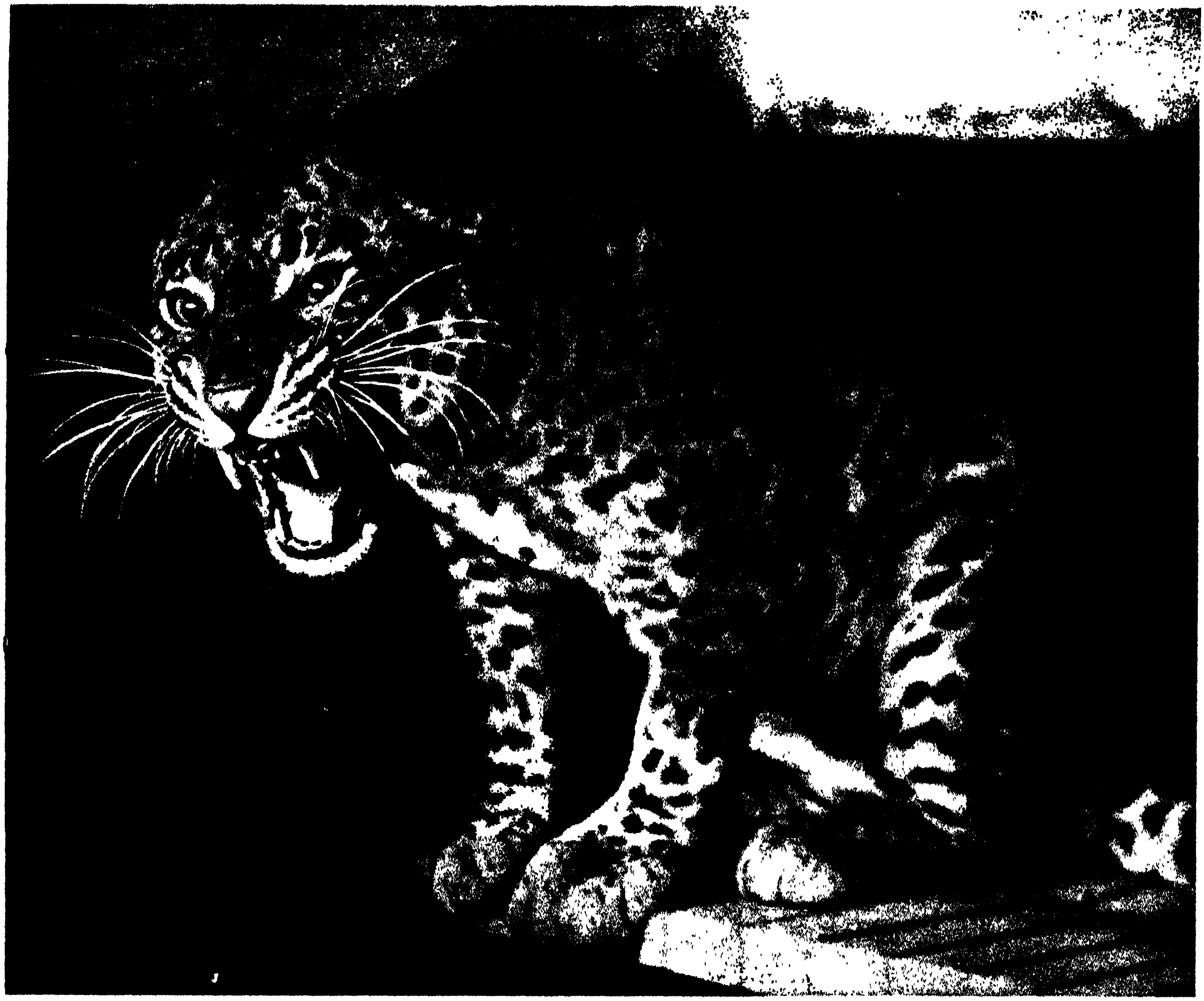
When other food is not easily available, the leopard will turn fisherman, grabbing the fish out of the water as a bear sometimes does. It will also rob birds' nests and claw the grubs out of rotten wood

Leopards do not often take to man-eating, but when they do they are more dangerous than man-eating tigers. to cover him, but you arrive at the place and find the leopard has vanished without leaving a trace of his line of retreat. A hunter has to be very silent and almost invisible in coming up to a leopard, but it is a fine sight to see him sitting with his head between his active paws, his ears laid back, his piercing eyes ever on the look-out, and to hear the coughing grunts or purring or snarling as now and again he pricks up his ears to gaze into the distance in consequence of some sound which has reached him."

the roof sufficiently large to allow a fowl to be lowered on a string. As soon as the leopard put its head out to seize the fowl, it was shot from the roof.

A leopard has also been known to enter a hut and snatch a child from its mother's arms. Others have taken the mother and left the child.

The leopard is so vindictive that, if wounded, it will turn and even pursue its tormentors into a tree. Its wounds are generally more dangerous than those of the lion or tiger, for it often eats putrid meat, and a



The leopards of the Old World are in appearance very much like the jaguars of the New World, but they can be distinguished from the jaguars by the fact that their spots are smaller, and where these are in the form of a ring they have no black spots inside the light centre

One leopard in Kashmir killed nearly a hundred people before it was slain and similar cases are reported from Africa.

The colouring of the leopard enables it to become almost invisible in the country which it haunts. A well-known traveller, Mr. J. Morewood Dowsett, says: "You see a leopard as plain as a pikestaff, you mark the spot and keep your eyes riveted upon it as you walk towards it with your rifle ready

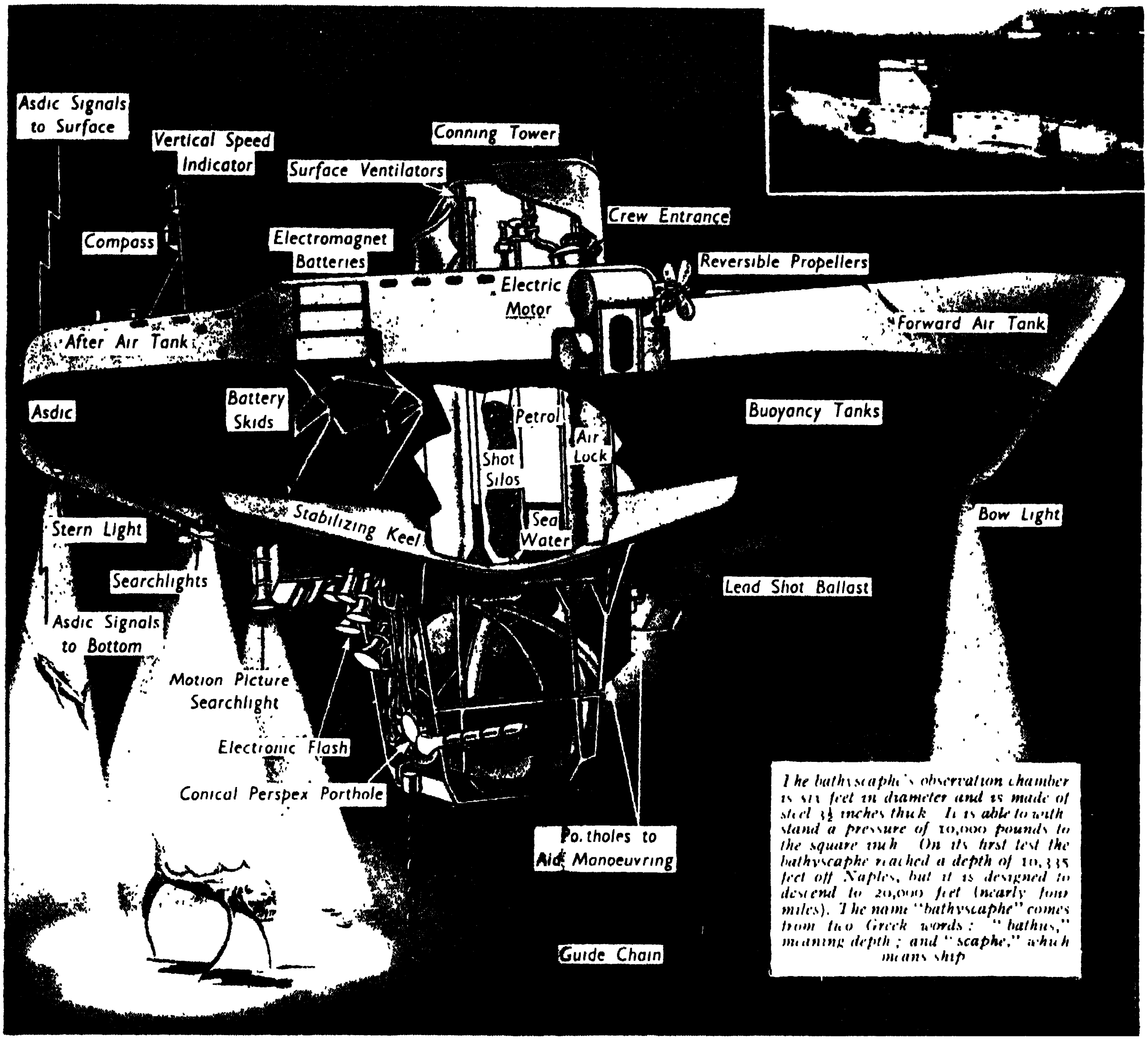
The cubs number anything from one to four in a litter, and when quite tiny make pretty playthings; but as they grow up they become dangerous and, it is said, can never be tamed.

Leopards are often daring enough to enter houses, and Mr Dowsett tells of one in Uganda which entered a hut and got under the bed waiting for its victim to come in But the door was shut, and then a hole was made in

scratch from its claws becomes very poisonous.

While the forest pigs are a favourite food of the leopard, it is only the young ones and the females that are attacked, for an old boar is a match even for a leopard or a tiger In a fight between a tiger and a boar in India which was witnessed by an English hunter, the tiger came off definitely second best.

BALLOONING TWO MILES UNDER THE SEA



The bathyscaphe's observation chamber is six feet in diameter and is made of steel 3½ inches thick. It is able to withstand a pressure of 10,000 pounds to the square inch. On its first test the bathyscaphe reached a depth of 10,335 feet off Naples, but it is designed to descend to 20,000 feet (nearly four miles). The name "bathyscaphe" comes from two Greek words: "bathus," meaning depth; and "scaphe," which means ship.

Exploring the bed of the sea in helmet and rubber diving suit is limited to comparatively shallow water because of the great pressure, which increases rapidly with depth. To enable observers to examine in safety the ocean bed thousands of feet below the surface, Professor Piccard, the Swiss physicist and balloonist, invented the bathyscaphe ; and it was particularly appropriate that he should do so, because diving by bathyscaphe is simply ballooning in reverse. Just as a balloon rises because its envelope is filled with a gas lighter than air, so a bathyscaphe sinks to the bottom of the sea by the weight of its ballast and then rises because its tanks contain a liquid which is more compressible than water.

As the drawing on this page shows, a bathyscaphe consists of a ball-shaped observation chamber fixed to the bottom of a hull like that of a submarine. The hull has a number of cylinders containing petrol, and a series of tubes containing iron filings which serve as ballast and are held in the tubes by electro-magnets. As petrol is more compressible than water, its buoyancy, and therefore lifting power, decreases during descent of the bathyscaphe, and increases during ascent. The ends of the cylinders containing the petrol continue as narrow tubes which turn over and end at the top of the hull, where they are open to the sea.

When the bathyscaphe submerges under the weight of its ballast, sea water enters the open end of the tubes and passes to the petrol, so compressing the spirit and reducing its buoyancy ; this makes the bathyscaphe descend deeper. To prevent descent from being too fast, ballast is released by switching off the current to the electro-magnets, so releasing iron filings held in the tubes. When the bathyscaphe nears the seabed, lengths of steel cable suspended from the hull come to rest on the bottom. This reduces the bathyscaphe's buoyancy and, propelled by its electrically-driven screws, it floats a few feet above the seabed. The bathyscaphe is brought to the surface by releasing more iron filings, so reducing its weight. As it rises, the petrol in the cylinders expands and forces out the sea water, so that the bathyscaphe becomes ever more buoyant.

The bathyscaphe's observation chamber accommodates two persons, and contains the controls, together with cameras and instruments for recording underwater conditions. Air within the chamber is supplied from oxygen cylinders and the stale air is disposed of by chemical absorbers.

Arranged along the bottom of the hull, but clear of the observation chamber underneath it, are a number of heavy metal weights held by electro-magnets. These weights act as a safety ballast, and if the iron filings fail to be emptied from their tubes, the current energising the electro-magnets is cut off and the weights are released. The sudden dropping of the weights gives such increased buoyancy that the bathyscaphe shoots to the surface at the rate of perhaps 100 feet per second.

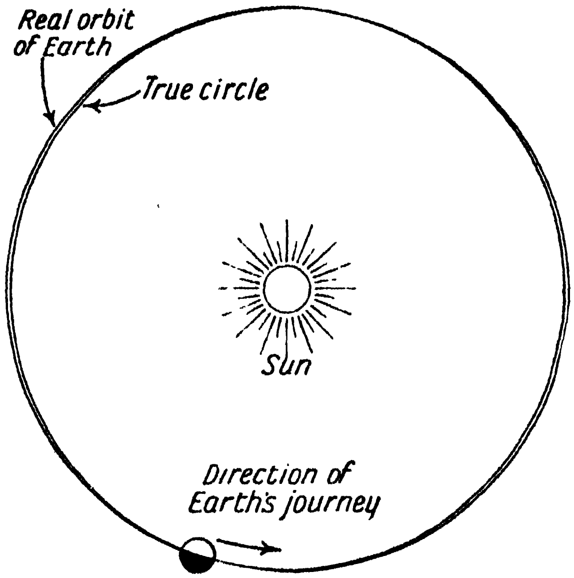
WHAT THE EARTH'S ORBIT IS REALLY LIKE

We are taught that the Earth travels round the Sun in an orbit which is not a circle, but an ellipse, and the diagrams in our geography and astronomy books always show this ellipse with one axis very much longer than the other.

It is perfectly true that the Earth's orbit is an ellipse and not a circle, but the ellipse is nothing like so pronounced as we see in the diagrams that are usually given In fact, it is so near a circle that a true diagram of it could not be distinguished from a circle except by placing a circle on the ellipse or by careful mathematical measurements.

Here is a diagram showing the Earth's orbit and a true circle It will be seen that the difference is scarcely perceptible. As a matter of fact, the Earth's orbit is not always of the same shape As the years go on it is getting less and less elliptical, and in about 24,000 years will be almost a true circle Then it will gradually become more elliptical again

What is it that causes this variation in the shape of the Earth's path round the Sun? Well, it is the attraction of the other heavenly bodies. All the planets travel round the Sun in ellipses, and some orbits are more elliptical than that of the Earth It is, of course, the gravitation or pull of the Sun which keeps the various planets travelling round and round instead of rushing off into Space But it must be remembered that although the Sun's pull is so tremendously great compared with that of the planets, yet all these planets have their effect upon one another Each pulls and is pulled by its fellows, and so we get the variations in the shape of the orbits. At one time it was thought that the Earth's orbit would go on becoming more and more eccentric, that is the Sun would be less and less near the centre of the orbit; thus one day the Earth would become parched when nearest to the Sun and frozen when farthest so that all life would come to an end. But we know now, that this will not be the case.



The Earth's orbit compared with a true circle

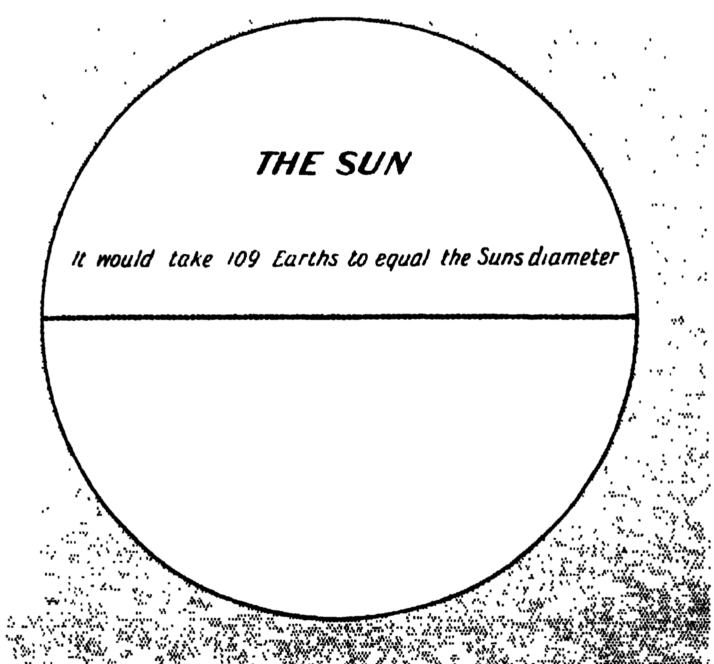
It was Johann Kepler the great German astronomer, who found that the Earth and the other planets move in elliptical orbits. By careful observation he discovered that the movement of the planets could only be explained in this way. It was a discovery of the greatest importance.

Kepler also showed that the Sun was not in the exact centre of the ellipse which formed the orbit of each planet, but at one of the foci. An ellipse is drawn by placing two pins side by side, putting a loop of string over them, and then with a pencil stretching the loop to its full extent and drawing a line right round. The nearer the pins are together the nearer a circle is the ellipse. The foci are the points where the two pins are.

THE SUN'S ENORMOUS SIZE COMPARED WITH THE EARTH

When we look up at the Sun it seems only about the same size as the Moon and, of course, the Moon is very much smaller than the Earth. While the Earth's diameter is 7,918 miles, the Moon's is 2,163 miles The difference in size is much more marked when we consider the volume or space the Moon occupies compared with the Earth. The Earth is fifty times as big as the Moon.

But how different is the size of the Sun Although as we look up at it in the sky it seems the same as the Moon it is really 1,305,000 times as big as the Earth. It is quite impossible for us to realise what this means, but the diagram which is given here will certainly help us to get some idea of how vast the Sun is when we compare it with the Earth



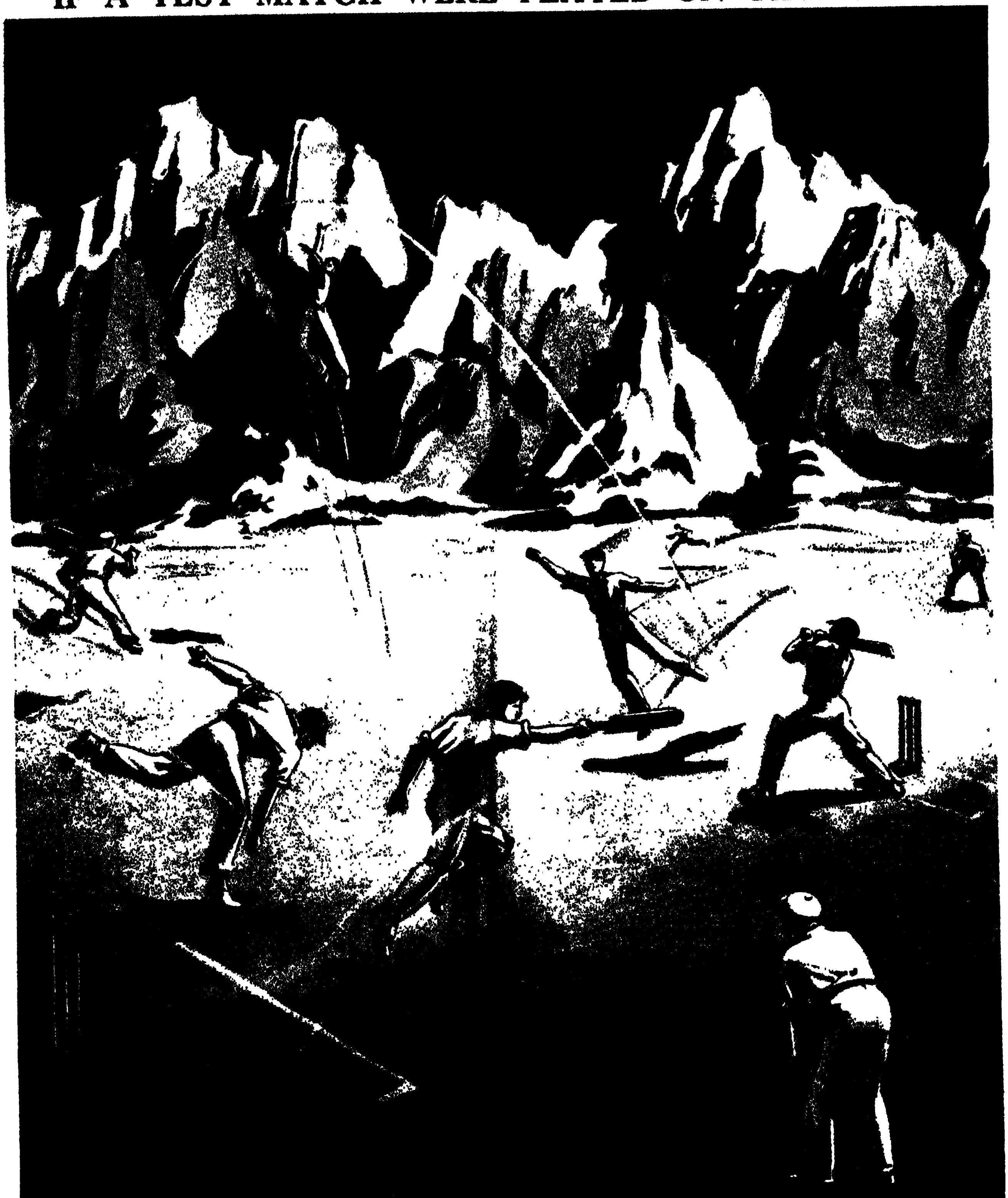
The size of the Earth when placed against the Sun's disc

The Sun's diameter is 865,000 miles, and it would take 109 earths placed side by side to reach across the Sun from one side to the other. The line of earths is shown in the diagram, and from this we can see what a mere speck the Earth is when seen against the Sun.

Of course, the matter of which the Sun is composed is not so dense or heavy as the material of the Earth, and so when we consider mass or weight the Sun is only 333,000 times as heavy as the Earth.

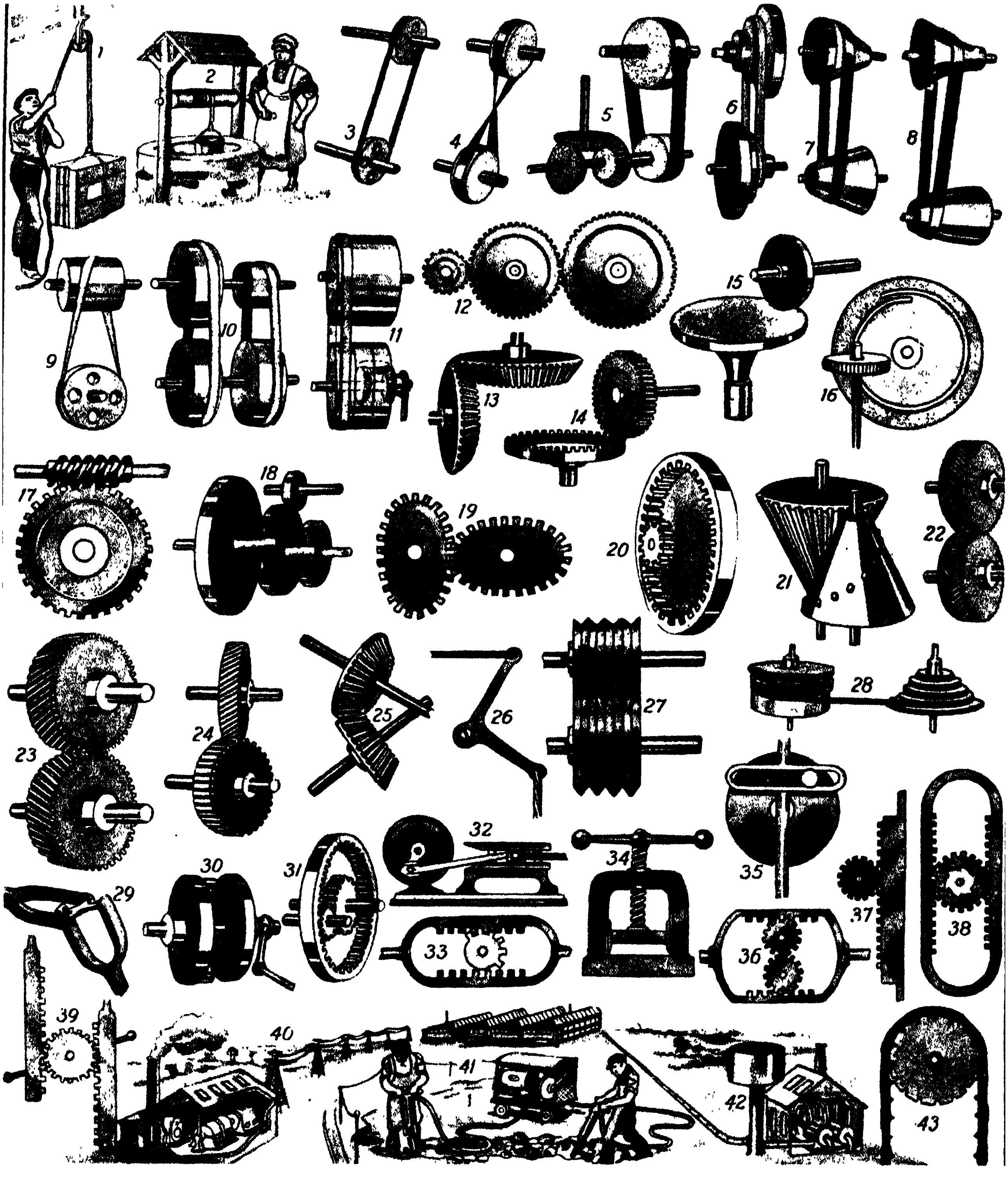
As the Sun gets cooler it will contract; its matter will become denser, and its size will consequently be less. Many of the other suns in the universe which we call stars are infinitely greater than our Sun. At one time the Earth was much bigger, but as it cooled down it contracted.

IF A TEST MATCH WERE PLAYED ON THE MOON



This imaginative picture shows us in vivid fashion how very different are the conditions on the Moon from what they are on the Earth. Of course, the absence of atmosphere and the tremendous variations of heat and cold would make it impossible for a human being to live on the Moon. But assuming these conditions could be overcome, we should find life on our satellite very strange indeed. The pull of gravitation being so much less, everyone could jump six times as high and run six times as fast and hit six times as hard as on the Earth, while the absence of air would mean that a ball when bowled or struck by a bat would go on without resistance for an enormous distance. A good blow would send the cricket ball hurtling over the mountains, and in most matches, if not all, every ball would be a lost ball. It would be practically impossible to catch balls travelling with such speed. Even in the daytime the sky would be quite dark, for the Sun's rays would reach the Moon direct without being broken up by nitrogen crystals as in our atmosphere

WAYS OF CONVEYING POWER TO A DISTANCE



Here are more than forty ways in which power is transmitted. The pulley and windlass in the first two pictures are familiar examples. In factories power is often conveyed from the engine to the machinery by belts working on pulley-wheels. When the belt works directly, as in 3 and 5 to 8, the power is transmitted in the same direction. When the belt is crossed, as in 4, the direction of motion is reversed. When the belt is half-turned, as in 9, the power is transmitted at right angles. By having pulleys of different diameters, as in 6, or cone pulleys, as in 7 and 8, the speed can be varied. Two different speeds can be transmitted by having both movable and fixed pulleys on the shafts, as in 10 and 11. No. 16 shows the transmission of rotary motion at right angles by means of a spur-gear and spiral thread on a disc wheel. Power is also transmitted by means of gear wheels, many examples of which are given. Sometimes the wheels work by friction only, as in 15, 18 and 27. To obtain varying or irregular speeds, such devices are used as in 19, 20 and 21. Sometimes the teeth of the gears are oblique, as in 22, 23 and 24. No. 26 shows power transmitted at right angles. No. 28 is a fusee formerly used in watches. No. 29 is a universal joint, and 32 shows a crank and piston, while 35 shows another form of crank motion with a slotted yoke. Various forms of rack and pinion are shown in 33 and 36 to 39. No. 30 shows a clutch, 40 electric transmission, 41 pneumatic and 42 hydraulic transmission. No. 43 shows chain and pulley transmission

THE NEED FOR TRANSMITTING POWER

One of the most important factors in the world's life is the transmission of power from the place where it is generated to the place where it is needed for the performance of work. There are many ways of transmitting power, and some of these are described and illustrated here

THE underground railways of London are full of trains, but they need power to drive them, and this power is made in a great central electric power station. That, however, would be useless if the power generated could not be transmitted through the tunnels to the trains. Even a boy on a bicycle might work the pedals as hard as he liked, but this would not make the bicycle go unless the power which he generated were transmitted to the driving wheel.

When man first began to do things he used power directly. If he wanted to get a log or boat down to the water, he pushed it or pulled it. If he wanted to get a pot on to a table or shelf he lifted it, but the amount of work that can be done in this way is very limited, and no machinery but the very simplest would have been possible if ways and means of transmitting power had not been invented.

Perhaps one of the simplest ways of transmitting power is that which we see in the knife-grinder's apparatus. His grinding stone must revolve, but if he were to turn this directly, he would have to use one hand for turning the wheel and have only one hand free for holding the knife. What does he do? He uses his foot for turning the wheel, and then transmits the power thus generated by means of a crank to the grindstone.

This method of using a crank is found in all sorts of machines, and particularly in the steam engine. The piston is driven to and fro by the steam, and then by means of a crank a wheel is turned and so the power is both transmitted and its direction changed.

Another comparatively simple way of transmitting power is by means of wheels called "pulleys" and belts. In factories, until the coming of electricity, the general method of transmitting power from the engine-room to the various parts of the factory was by means of revolving shafts with pulley-wheels fixed to them over which ropes or belts passed.

In this kind of transmission the belt sometimes passes from the driving wheel of the engine to a pulley or wheel attached to a shaft, so that both rotate in the same direction. The driving wheel of the engine thus, by means of the pulley and belt, turns the shaft and then from the shaft other belts and pulleys carry the power elsewhere, and so all the machinery of the factory can be kept working.

Sometimes it is desirable to rotate the shaft in the opposite direction to that in which the driving wheel of the engine is turning. This is done by crossing the belt and then the one wheel going one way transmits its power in such a manner as to turn the other wheel the other way. By varying the diameters of the pulleys, different speeds can be obtained.

Thus, the belt passing over a large driving wheel, if it goes round a small pulley, will greatly increase the speed of the shaft on which the pulley is fixed, and on the other hand a belt passing round a small driving wheel and going over a larger pulley will rotate its shaft much more slowly. Sometimes, by giving the belt only a quarter twist, a shaft can be rotated at right angles to the driving-wheel.

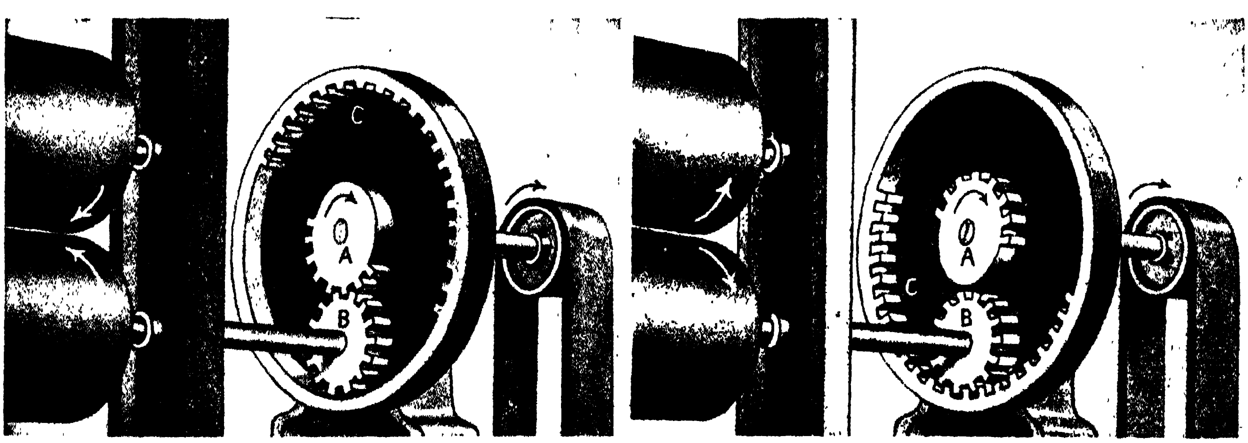
There are all kinds of variations of this device for transmitting power. By having a number of pulleys side by side of different diameters, the belt can be transferred from one to another and different speeds obtained at different times. Occasionally cone-shaped pulleys are used, as in cotton machinery. These allow of minute and continual change of speed by simply moving the belt in one direction or the other along the pulleys.

Another method of transmitting power is by means of gearing, that is, by means of a combination of wheels in contact with one another. Generally, the wheels have teeth and these engage with the teeth of other wheels turning them, as we see in the works of our clocks and watches, or on a larger scale in the mangle at home.

Occasionally, however, the wheels have no teeth or projections of any kind; they turn together by the friction of their surfaces.

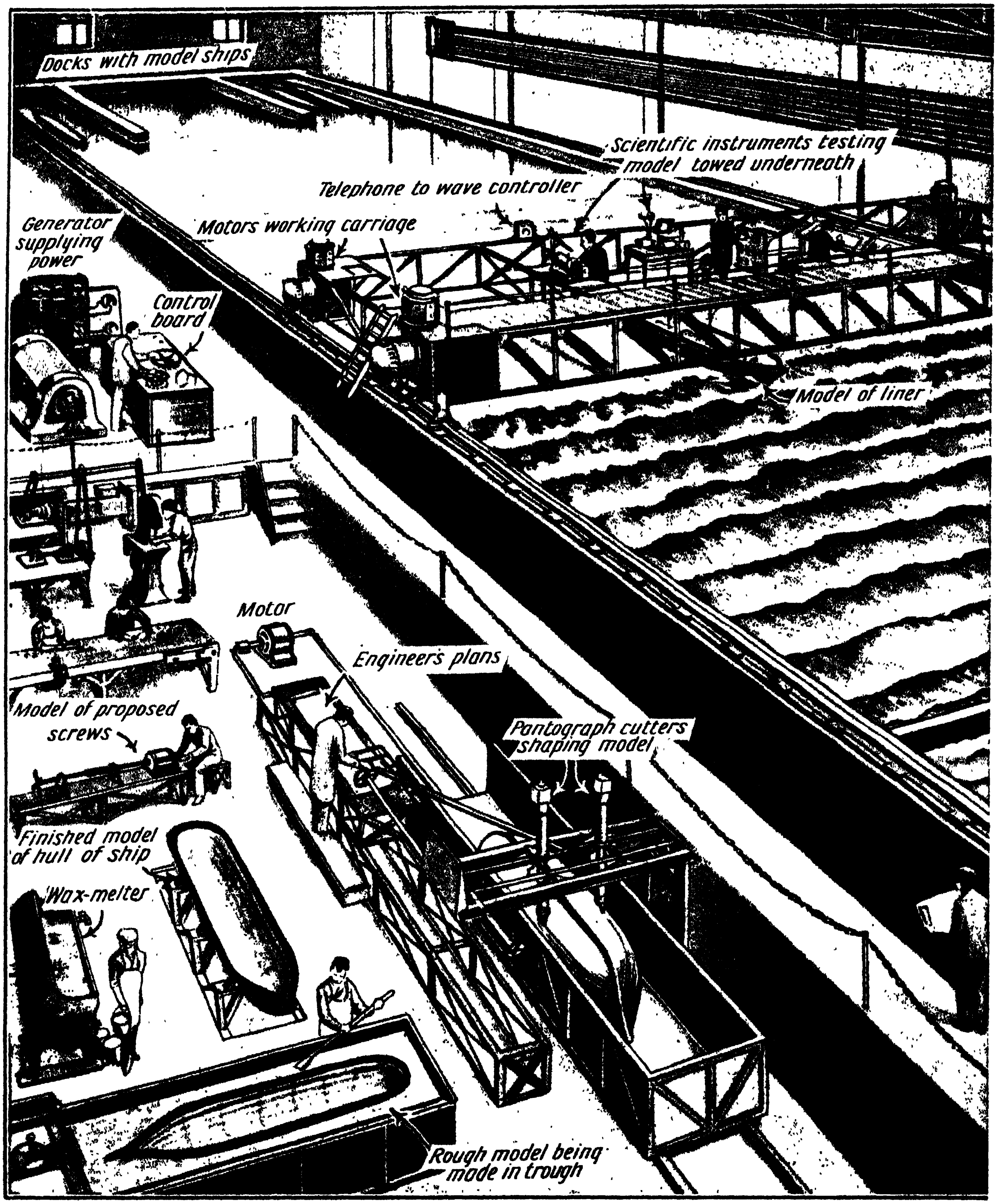
Of course in modern times man has found more efficient ways of carrying power over the long distances than the old method of the shaft and pulleys with leather or rope belts. He now transmits the power of electric generators hundreds of miles by means of cables.

Power is also transmitted by means of steam, as in the steam engine, the turbine and so on, and it is transmitted by water, as in the hydraulic machinery, and by air as in pneumatic drills, hammers, and so on.



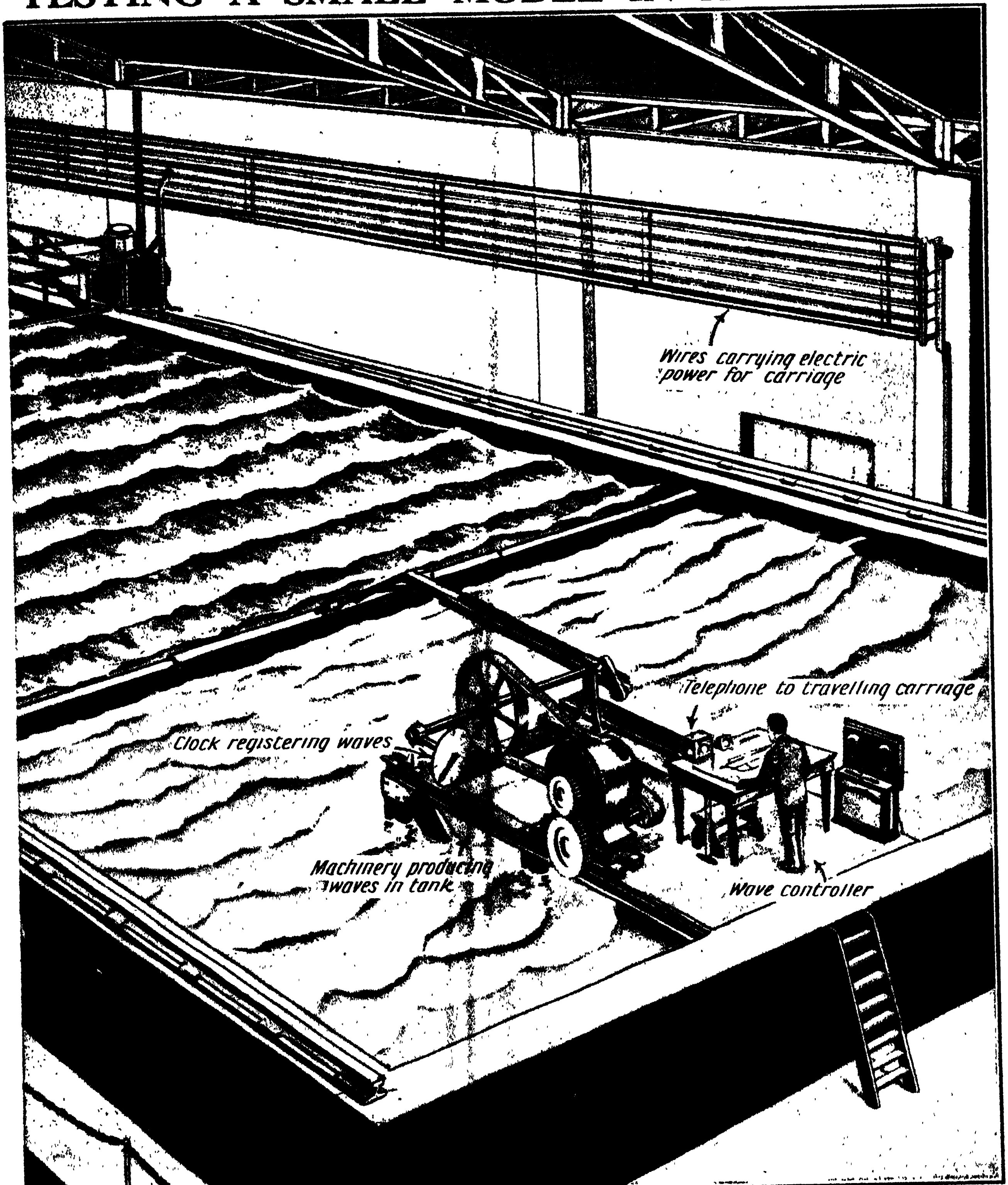
This picture shows how the gear wheels of a big power mangle turn the rollers first in one direction and then in the other direction. When the big disc C is turned by the belt and pulley, as in the left-hand picture, the teeth of the wheels A and B engage and the rollers turn inwards. When the teeth of B reach the toothless part of A, as on the right, they engage with the internal teeth of C and the rotation of the rollers is reversed. Owing to the large diameter of C and the small diameter of B the speed is greatly increased

HOW A STEAMER'S DESIGN IS SETTLED:



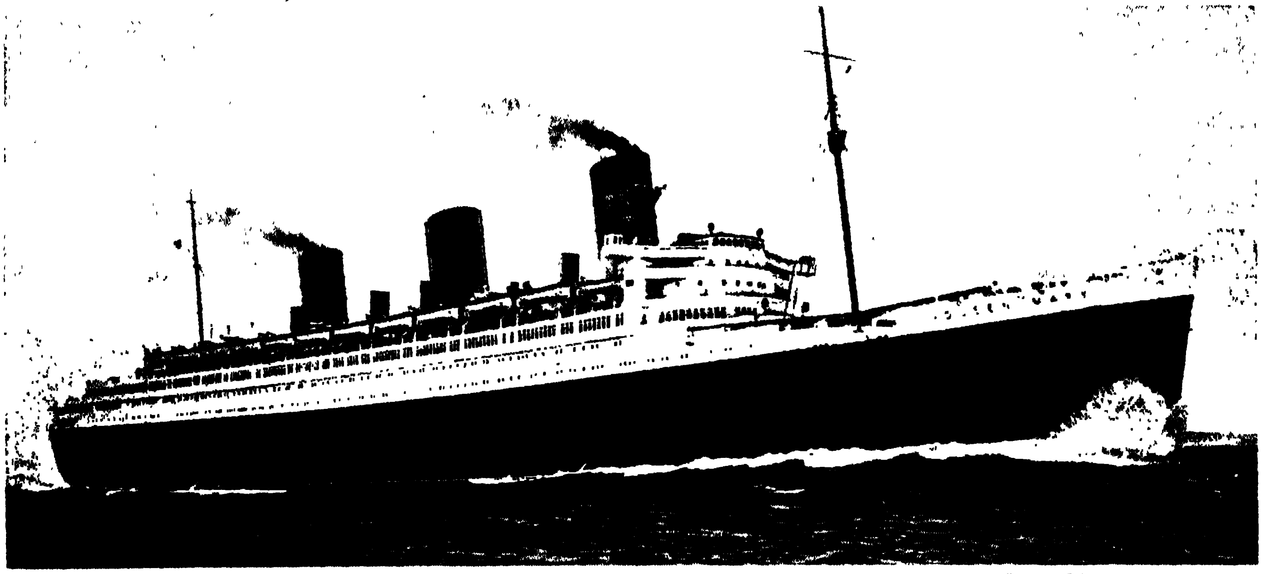
Before anything is done towards building a great Atlantic liner the design has to be settled in such a way that all those responsible can be absolutely sure that it is the very best design conceivable. The first step is the drawing of the plans on paper. Before the actual building begins a small scale model of the hull is made and tested in a huge tank with artificial waves of various dimensions, the whole being scientifically carried out and the minutest results noted. This is done at the National Physical Laboratory at Teddington, and on these pages we see how the design of a new liner is tested. The plans are taken to the laboratory, where, by means of cutting tools attached to an instrument called a pantograph, a wax model on a small scale is made to represent in the minutest detail the proportions of the plans. The wax model is first made roughly in a trough and is then shaped exactly by the pantograph cutters, as shown on the left of our drawing. The pantograph, as probably most readers will know, is an apparatus by which a small scale drawing can be made from a larger one, but in this case the pantograph has cutters attached, and as a motor slowly moves the wax model along in a

TESTING A SMALL MODEL IN A BIG TANK



framework the cutters shape it to the plans. The wax hull is now placed under an electrically propelled carriage, which moves on rails on each side of a huge tank 550 feet long and 12½ feet deep. The rails on which the carriage moves are not exactly horizontal. They are built to the curve of the Earth's surface, so that they will at any particular point be uniform with the surface of the water. The carriage then moves along the tank, taking the hull with it, and a machine at one end produces waves of various dimensions so that the wax ship can be tested under all the possible conditions that the finished liner will be likely to meet in the ocean. Scientific apparatus on the moving carriage records all kinds of details as the test is made, and by means of these records the scientists are able to indicate where improvements can be made in the design. The modifications thus made in the design often result in a very large reduction in fuel consumption, which, of course, means less running expense. Scale models of the ship's propellers are also made, but these are tested in long, curved tubes through which water flows. This gives data as to how the propellers will behave at sea

WHY 80,000 TONS OF STEEL CAN FLOAT



Steel is about eight times as heavy as water, and yet we see in this photograph of the Cunard-White Star liner Queen Mary a mass of more than 80,000 tons, most of it steel, lightly floating in water. What is the explanation ? It is really quite simple. If the masses of steel of which ships are made were compressed together into solid blocks they would sink very quickly, but by being spread out into the shape of a vessel, with thousands of cubic feet of air inside, they float, because their total weight is less than their own volume of water. A solid body will always float in liquid if its weight is less than the weight of a similar bulk of the liquid, because the upward pressure or buoyancy of the liquid is greater than the downward force of gravity, that is of the body's weight. A solid piece of iron or steel sinks in water because it is heavier than an equal volume of water, but if it is made into a hollow vessel, so that when only partly immersed it displaces a quantity of water equal to its own weight, it floats. The weight of a ship and everything on board is always equal to the weight of water that the submerged part of it displaces.

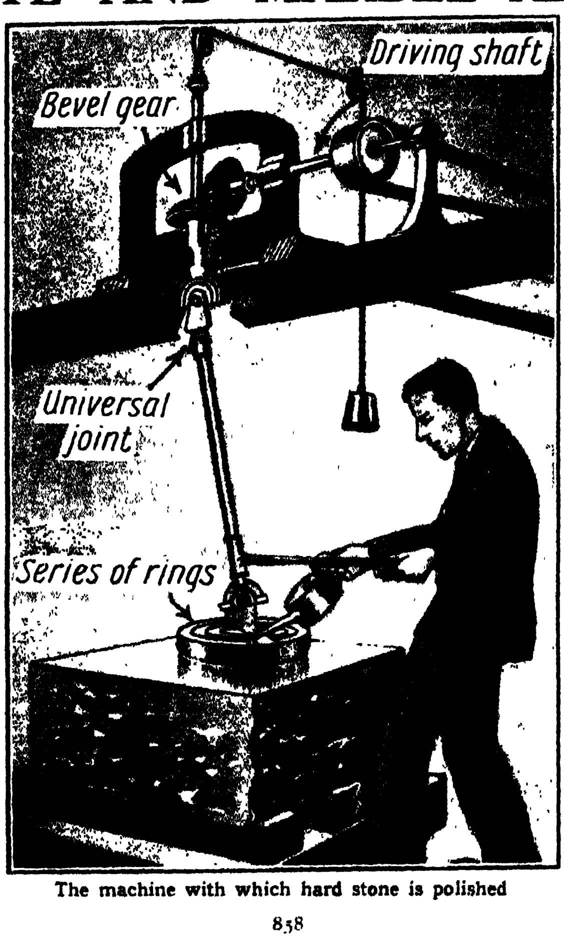
HOW GRANITE AND MARBLE ARE POLISHED

We have probably wondered when we have seen a beautifully polished block or pillar of granite or other stone how the hard rock had obtained this glaze.

The picture that is given here shows the apparatus with which the stone is polished. Of course, before the actual polishing takes place the surface is worked as level and smooth as possible, and then the grinding begins with the apparatus shown.

The actual part of the machine that is in contact with the stone is known as a lap, and consists of a series of cast iron rings arranged round one another. Between the rings very fine sand and water are fed from time to time, and by means of a handle the workman rotates the lap on the stone. There are universal joints at each end of the arm or rod which holds the lap and connects it with the driving shaft, so that it can be turned in all directions without difficulty. The handle with which the workman guides the lap has a swivel connecting it with the rod.

The apparatus is worked by bevelled gearing and this is driven from a shaft. The gearing rotates the lap of iron rings rapidly while the workman is moving it about over the surface of the stone. The upper vertical shaft on which the bevelled gearing turns is balanced by a weight, so that the rod connecting the machinery, with the lap can move freely at any angle.

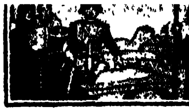


The machine with which hard stone is polished

There is an old saying that "a constant dropping wears away stone," and it is equally true that a constant rubbing wears away stone. The repeated friction of the lap with the wet sand on the surface wears away the minute inequalities till at last the surface becomes perfectly smooth.

The harder stones like granite and serpentine will take a finer polish than softer stones like sandstone and limestone. Many stones which look dull in the rough state are exceedingly beautiful when polished, and this is nowhere seen more clearly than in the case of the grained marbles.

In sculpture the polishing of the marble is carried out in a different manner. In order to give the sculptured figure a smoothness and gloss, the surface of the marble is first rubbed well with freestone. Then it is worked all over with pumice-stone, and after it has been rendered quite smooth by these processes, it is last of all rubbed again and again with very fine emery powder, which produces the desired glossy surface giving a soft effect.



A TERRIBLE TALE OF THE HIGHLANDS

Much of history is a stern and tragic business, but in all the annals of the British Isles there is no darker story than the Massacre of Glencoe. Here the true facts of this episode are given in detail

William of Orange was never a very popular king. He had served the purpose of the English by relieving them of the troublesome Stuarts, but he was cold in his manner and rough in his ways, and as he was constantly asking for money to carry on his wars against Louis the Fourteenth of France, there were many who wondered if they had not made a mistake by putting him with his wife on the throne of England.

Even his sister-in-law Anne and the Duke of Marlborough, who had helped him to the throne, intrigued against him, and there were risings in both Ireland and Scotland, for the Stuarts had many sympathisers.

William went to Ireland himself, and led his army against James's forces, defeating them completely at the battle of the Boyne. There was one thing, at any rate, about William that the English liked, and that was his bravery. He went himself into the fighting line, where he was wounded, but he had the wound bound up and continued in the thickest of the fight, holding his sword in his left hand, while he managed his horse with the wounded right.

Safety First for James

This was very different from James, who watched the battle from a safe place on a distant hill, and as soon as he saw his men beaten left them in the lurch, galloped off to Dublin, and soon scuttled back to France. No wonder one of the Irish officers said later on to an Englishman: "Change kings with us and we will fight you again."

In Scotland, when the bishops were driven out and Presbyterianism was declared to be the religion of the country, some of the Scottish nobles, finding these things distasteful, decided to draw the sword for James, and they roused some of the clansmen. One of these nobles was Viscount Dundee, perhaps more familiar as Graham of Claverhouse. We all know the poem of Sir Walter Scott, which begins:

> To the Lords of Convention 'twas Claver'se who spoke,
> "Ere the King's crown shall fall there are crowns to be broke;
> So let each Cavalier who loves honour and me,
> Come follow the bonnet of Bonny Dundee."

He gathered a force of clansmen and met William's troops in the Pass of Killiecrankie. The English had been supplied with bayonets, a new French invention which was intended to make the men pikemen as well as musketeers. But those early bayonets were very different from the weapons used to-day. They had to be fixed in the muzzles of the guns, and it took some time to get them into position.

The English soldiers toiled up the steep hillside to attack the Highlanders, and after firing their guns and killing Dundee, they prepared to fix their bayonets. But the clansmen were too quick for them, and rushing down with their broadswords did such service that they soon defeated William's force.

So long as the Highland clans were in sympathy with the Stuarts, King William felt that there was danger to his throne, and he and his friends decided that the best plan would be to get the Highlanders to submit to the new rule. They were all very poor, and so a sum of £15,000 was set apart to divide among the chiefs of the clans in order to induce them to submit. Then a day was fixed, December 31st, 1691, as the last day on which they could take the oath of allegiance to King William. If any stood out after that period, it was declared by proclamation, they would be subjected to fire and sword.

The treacherous troops were welcomed and given every hospitality by the clansmen

This proclamation had been framed under the influence of a Scotsman, Sir John Dalrymple, who was known as the Master of Stair. He and the Earl of Breadalbane were very angry with the Highlanders because a scheme of theirs for bringing the whole of the clans over to the side of William had failed, and they now determined to be revenged for what they considered an affront. They hoped and believed that some of the more stubborn chiefs would hold out beyond the date appointed for submission, and we know from their letters that they had determined if such a thing happened to inflict upon the culprits the most severe and terrible punishment.

But news of their game reached the chiefs and these, one by one, submitted to the government and took the oath of allegiance to William of Orange. It is said that they did so by secret orders of King James who, realising the evil designs of the Master of Stair, wanted to save his friends from death. If this is true, it is the best thing James ever did.

A Foolish Chieftain

As the chiefs submitted and so could not be punished on the ground of delay, the Master of Stair, who was a lawyer, did his best to find some legal flaw in the terms so that he could exclude certain of the clans from the benefit of the indemnity and make an example of them. But he failed, and it seemed as if the whole of the clans would be safe, when the foolishness of one of their chiefs gave Stair the opportunity to exercise his wickedness.

MacIan of Glencoe was an old man of stately and venerable person, whose word was greatly respected by other chieftains. He had taken part in the Killiecrankie campaign, and when later the insurgent highland chiefs had a conference with the Earl of Breadalbane for the purpose of arranging an armistice, MacIan was present and charged Breadalbane with trying to keep back

part of the money given to him for distribution among the chiefs. The Earl denied this angrily, and in his turn charged MacIan with stealing cattle from the lands surrounding Glencoe. Naturally no love was lost between the two men, and MacIan himself had been heard to say more than once that he dreaded mischief from the Earl of Breadalbane.

One would have thought that, knowing the power of the Earl, the Glencoe chieftain would have hastened to make his submission in good time so as to be sure of benefiting by King William's indemnity. But for some reason or other, although he saw all his friends taking the oath of allegiance, he held out, and only went to make his submission on December 31st, that is the last day allowed by the Proclamation. Probably the old chief took pride in being the last to give in.

But unfortunately he went to the wrong place, and the wrong man. He found that Colonel Hill, the Governor of Fort William, to whom he tendered his oath of allegiance, had no power to receive it, being a military and not a civil officer. The old chieftain was now in great distress, but Colonel Hill, who sympathised with him, gave him a letter to Sir Colin Campbell, Sheriff of Argyllshire, requesting that official to receive the "lost sheep" and administer the oath so that he might have the advantage of the indemnity.

An old domestic woke them at four o'clock in the morning and told them to rise and fly for their lives

One Day Late

MacIan hurried off from Fort William to Inverary, but a heavy snowstorm came on and made the roads almost impassable. The result was that although he went as quickly as he could, the unfortunate chieftain only reached Inverary on January 1st.

The sheriff, however, being a decent man and realising that MacIan had complied with the spirit of the Proclamation in submitting within the given period, though by a genuine mistake he had applied to the wrong person, decided to administer the oath of allegiance.

MacIan, supposing that everything was now safe and that he and his people were under government protection, returned to his home. He gathered the clan, told them what he had done, and ordered them to live peaceably and give no cause of offence to anyone.

But the chief had reckoned without the Master of Stair, a friend of Breadalbane, and even more vindictive than he. That official procured from King William on January 11th orders to execute with fire and sword all clansmen who should not have made their submission within the time appointed. The King's order, however, gave power to extend mercy to those clans which even after the time was passed should still come in and submit themselves.

Stair, seeing himself baulked of his revenge on the chief of Glencoe and his people, obtained under some pretext a second set of instructions, holding out the same indulgence to all other clans which should submit themselves at the last hour, but closing the gate of mercy against MacIan and his men who, it must be remembered, had already submitted.

In the new order occurred the words, "As for MacIan of Glencoe and that tribe, if they can be well distinguished from the rest of the Highlanders, it will be proper for the vindication of public justice to extirpate that set of thieves."

The wicked ingenuity of this will be seen, for all the clans including that of Glencoe had already submitted. Yet the order presumes that the Glencoe people had not given in their allegiance. Probably King William, although he signed the orders, knew nothing of the real facts of the case.

There is no doubt whatever about Stair's wickedness. His letters to the military officers directing how the King's orders were to be executed show his fierce determination that the revenge should be as savage as possible. "The winter," he said, "is the only season in which the Highlanders cannot elude us or carry their wives, children and cattle to the mountains. They cannot escape you, for what human constitution can then endure to be long out of the house? This is the proper season to maul them in the long dark nights."

He even expresses his joy that Glencoe had not submitted within the prescribed time, and declares his hearty wish that others had followed the same course. He expresses to the military authorities the desire that the thieving tribe of Glencoe might be routed out in earnest, and he gives directions that every pass by which the victims could escape shall be secured. "To plunder their lands or drive off their cattle would," he says, "be only to render them desperate; they must be all slaughtered and the manner of execution must be sure, secret and effectual."

These terrible instructions were sent to Colonel Hill, the Governor of Fort William who, being a decent, kindly man, tried for some time to avoid executing them, but when at last he had to obey he sent the orders on to Lieut.-Colonel Hamilton, telling him to take four hundred men of a Highland regiment belonging to the Earl of Argyll and fulfil the royal mandate. The choice of the executioners was deliberate, for the men selected were Campbells, who had long had a bitter feud with the Macdonalds of Glencoe. There was no doubt that they would do the fell work far more thoroughly and more zealously than strangers.

Scot Against Scot

As Sir Walter Scott has emphasised, it is quite unjust to suggest that the massacre which followed was committed by English troops. The whole dreadful deed was planned by Scotsmen and carried out by Scotsmen.

By the end of January a party of the Earl of Argyll's regiment commanded by Captain Campbell of Glenlyon, approached the valley of Glencoe. MacIan's sons, with several others, went to meet them and asked whether they came as friends or foes. The officer replied that they came as friends and had been sent to take up their quarters for a time in Glencoe so as to relieve the garrison at Fort William, which was very overcrowded.

They were thereupon welcomed by the chief and his followers, and for fifteen days were given every hospitality. They lived in the houses of the people, were entertained at meals, played cards

with the clansmen and thoroughly enjoyed themselves. When we remember what was intended, it seems the very refinement of cruelty that one of the sons of MacIan, destined for death, was the husband of a niece of Glenlyon, the commander of the troops.

But Glenlyon seems to have been a worthy servant of those who had planned the dreadful deed. When he had been living on the hospitality of the Glencoe clansmen for a fortnight, he received orders from his commanding officer, Major Duncanson, directing that all the clansmen under seventy years of age were to be cut off and that the government was not to be troubled with prisoners. The order was as follows:

"You are hereby ordered to fall upon the rebels and put all to the sword under seventy. You are to have especial care that the old fox and his cubs do on no account escape your hands; you are to secure all the avenues that no man escape. This you are to put in execution at four in the morning precisely, and by that time, or very shortly after, I will strive to be at you with a stronger party. But if I do not come to you at four you are not to tarry for me, but fall on. This is by the King's special command for the good and safety of the country that these miscreants be cut off root and branch. See that this be put into execution without either fear or favour else you may expect to be treated as not true to the King or Government, nor a man fit to carry a commission in the King's service."

Glenlyon, as soon as he received the letter, lost no time in carrying out the dreadful order. Up to the last he lulled the suspicious of his victims by courteous familiarity. He even on the day before the massacre visited the house of his niece's husband, Alaster MacDonald, MacIan's second son, and drank with him. He and two of his officers accepted an invitation to dine with MacIan on the following day, although they knew that for the chieftain the sun would never rise. He even played cards with the two sons of the chief.

But on the evening preceding the massacre MacIan's two sons noticed that the sentinels everywhere were doubled, and John, the elder brother, had heard some of the soldiers muttering something about not liking the nature of the service they were engaged in.

On the eve of the massacre, therefore, they went and questioned Glenlyon and found him and his men preparing their arms as though for a fight. They expressed their alarm, but the officer laughed at their fears and told them that his troops were getting ready for an expedition against some local robbers. "If anything evil had been intended," said the treacherous and crafty Glenlyon, "would I not have told Alaster and my niece?" The young men were reassured at this, and went back home to bed.

Treachery in the Night

But just after 4 o'clock they were awakened by an old domestic, who told them to rise and fly for their lives "Is it time for you to be sleeping," she said, "when your father is murdered on his own hearth."

The young men hurried out in terror, and heard coming from all parts of the glen the sound of musket fire, the cries of the victims, and the shouts of the murderers. It all seemed incredible, but they fled, and by their knowledge of the almost inaccessible cliffs managed to escape.

The morning after the Massacre of Glencoe From the painting by J. B. Macdonald in the National Gallery of Scotland

It appeared that at about four a party of soldiers went to MacIan's house and knocked for admittance, which was at once granted. The officer in charge of this party was one of the expected guests of the family meal that day. Without the slightest hesitation he shot MacIan dead by his own bedside. The chief's aged wife was so badly treated that she died the next day. The servants and others in the house were killed.

Dreadful Work all Over the Glen

Then the dreadful work went on all over the glen. No regard was paid to the order which said that only those under seventy were to be slain. Those more aged were also killed, as were also some of the children. In one house nine clansmen were assembled round their morning fire, when the soldiers entered and fired. Four were slain. The owner of the house asked that he might be put to death in the open air rather than under the roof.

"For your bread which I have eaten," said the soldier in charge, "I will grant the request." He was accordingly dragged outside, but just as the soldiers were presenting their muskets to shoot him he quickly cast his plaid over their heads and taking advantage of the confusion ran away and escaped up the glen.

The soldiers set the huts on fire, and the women and children had to flee amid snow and storm in the winter darkness. Many of them were frozen to death in the inhospitable mountains.

The number killed in the glen was thirty-eight, while of those who escaped in the darkness many perished from starvation and exposure.

As soon as the news spread it caused a feeling of horror, and King William's reputation was stained for all time. But the villain of the piece was the Master of Stair, who had deliberately planned the whole thing. The massacre had results, however, which he never foresaw. For the first time in history the Lowland Scots showed compassion for Highlanders, whom hitherto they had always treated as thieves and savages undeserving of any mercy.

The Scottish Parliament indignantly called on King William to dismiss the Master of Stair from office, and there was an inquiry by a Royal Commission into the whole incident. Stair was obliged to retire from public affairs, and when he succeeded to his father's title of Viscount Stair, he dared not for some years make his appearance in parliament. Later on, however, he was made an earl, and the other agents of the massacre all went unpunished. The King's reputation was tarnished, and the Massacre of Glencoe stands out as one of the dark blots in British annals.

There is an interesting sequel to the story. When the Young Pretender raised an army and marched through the Lowlands in 1745, among other Highlanders who joined his standard was a descendant of the murdered MacIan of Glencoe. He took with him 150 of his men.

The route of Charles Edward's army brought them near a beautiful seat of the Earl of Stair, and it was feared by the Prince and his advisers, that the Glencoe clansmen would take advantage of this chance of revenge by burning or plundering the mansion of the descendant of their persecutor. Such an act would do the Prince's cause no good, and so it was decided to place a guard there to protect Stair's house. But when MacIan's descendant heard this, he insisted that he and his men should form the guard. The chieftain's request was granted and the property was safely protected.

GLIDING EASILY OVER THE SLIPPERY ICE

Once the difficulty of keeping balance on a slippery surface has been mastered, skating is not difficult, as the earnest young skater on the left is successfully demonstrating. Above, two small girls have no difficulty in performing a complicated dance on the ice. The photograph below is of a scene from the pantomime Babes in the Wood performed by skating actors and actresses. Spectacular ice shows of this kind are now a popular entertainment

WHY WE FALL SO EASILY ON ICE

How do we find it so difficult to walk across the ice, or across a shiny ballroom floor? And why is it more difficult to walk with new shoes on our feet than when we are wearing our old ones? It is all a question of friction, one of the most important facts in our lives. We read many facts about friction on pages 201 to 203, and here is some more interesting information upon this subject

It is very easy to slip and fall on the ice or on pavements covered with frozen rain; in fact, on such surfaces it is extremely difficult for us to keep our balance at all. In another part of this book we read of the apparatus in our heads which enables us to keep upright in the ordinary way, and if we are healthy it is quite easy to walk on an ordinary rough surface like the road or pavement or a carpeted floor. But on a slippery surface it is difficult, and indeed, if the surface is very slippery it is practically impossible.

The most dangerous formation of ice on roads and pavements is what is known as a silver thaw. This is a natural phenomenon produced when a warm, damp wind blows over a cold surface. The moisture in the wind becomes condensed and frozen into a thin layer of ice on the surface.

The whole of the roads and pavements in towns often become coated in this way in winter, the effect being increased by a fall of rain, which freezes the moment it reaches the ground. People slip and fall in all directions, and many of them hurt themselves. Vehicles skid and their wheels can grip the road only if the ice has been strewn with sand or melted with salt.

Why do people fall so easily when walking over ice? Well, the reason is that ice, being so smooth and slippery, the friction between the soles of the shoes and the surface of the ground is reduced to a minimum. When walking there must be friction or we could not get along. When we put one foot down and bring the other forward there must be friction between the sole and the ground in order that our foot may get a grip and not slide forward.

The friction being almost entirely removed when we walk on ice, the resting foot cannot get a grip and slips forward as we try to bring the other foot in front. The result is that our centre of gravity gets misplaced, and we are in what men of science call a state of unstable equilibrium (we read about this on page 34).

We know how easy it is to slip on a banana skin. The skin slides on the pavement, taking us with it. Well, during a silver thaw it is as though the whole of the ground was covered with banana skins.

Losing our equilibrium we go over, falling, perhaps, on one knee, but as soon as this comes in contact with the ice it also slips. Then we put out our hand to break the fall, and that slides as well. Nothing can get a grip on the slippery surface, and the result is that the final speed of the fall is such that a great strain may be set up at various points of the body, causing some of our bones to break.

It might be asked why, if we cannot walk on the ice, are we able to slide or skate over it without falling down? Well, of course we have to learn to do this in the same way as we have to learn to ride a bicycle, but with a little practice it is quite easy to slide or skate without falling.

We have already read on page 62 about Newton's First Law of Motion, which says that "every body continues in its state of rest or of uniform motion in a straight line, except in so far as it is compelled by external force to change that state."

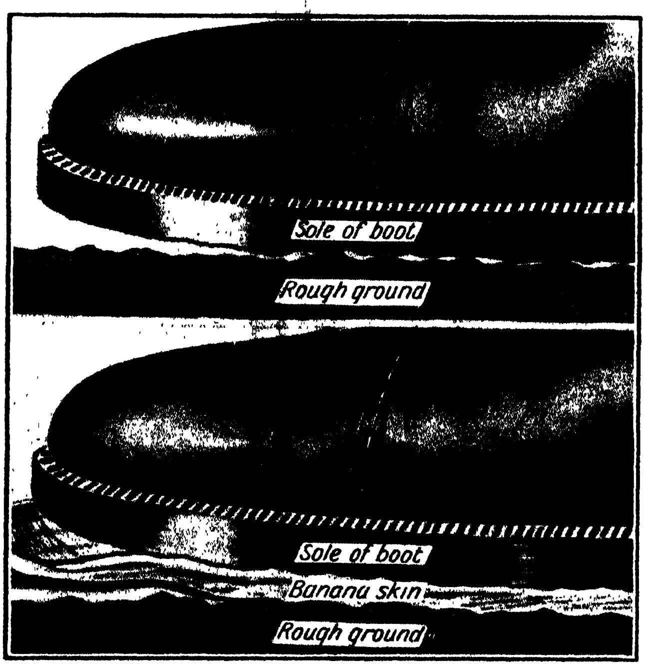
Now, when we push ourselves off with one foot in sliding or skating, giving ourselves a rapid forward motion, there is just as much tendency for us to overbalance and fall as when walking on the ice, but the faster the motion forward of the person skating or sliding, the less effect the pull of the Earth has on his body, because the rapid forward movement to some extent counteracts the pull of gravitation.

It is therefore much easier to keep one's balance when sliding or skating quickly than when trying to go slowly, exactly as it is easier to ride a bicycle quickly than to ride it slowly. The less the motion forward the more the tendency is to overbalance.

From what has been said it will be clear that our needs are quite different when walking from what they are when skating or sliding. In the one case we need soles to our shoes that are not too smooth and shiny, and ground that is fairly rough without being too rough and irregular. In fact, in walking we need just sufficient friction between our soles and the ground to give a grip without these surfaces being so rough as to make walking a difficulty and hardship.

In skating and sliding, on the other hand, we want to get rid of friction as much as possible. The smoother the skates and the smoother the ice the more rapidly shall we be able to move over the surface. In other words, if the ice is very smooth, skating becomes easier, while walking becomes more difficult.

We see the same thing indoors when we try to walk across a polished dance floor while wearing new shoes that have their soles very shiny. Unless we are exceedingly careful we shall slip down. But



We can walk on the ground because the slight inequalities of the soles of our shoes fit more or less into the inequalities of the ground, as shown in the upper picture, setting up friction, which enables us to get a grip. If, however, we step upon a banana skin, the inequalities of our soles and the ground are filled up with the soft material of the skin, and our foot then slides without friction over the ground

if, instead of walking on this floor, we are going to dance, especially if we are going to waltz round and round, then the smoother the floor and the smoother the soles of our shoes the more easily we shall be able to carry out the movements of the dance Here, however, friction must not be entirely abolished or we should not get the grip to start off in our dancing.

In some ways life may be regarded as a battle in which friction acts sometimes as our friend and sometimes as our foe Friction is our foe when the ice gets rough and our skate blades rusty, as then it reduces our speed and makes skating less easy But if the ice cracks and we go into the water, and someone throws us a rope, then friction is our friend, as it enables us to grip the rope so that we can be drawn out of the water. If there were no friction, the rope would slip right through our hands when our friends started to pull. We could not even make use of a loop in the rope to slip our arm through, for directly the rope was pulled the knot would come undone.

A champion skater skimming over the ice at about 25 miles an hour He is able to attain this great speed because the smoothness of his skate blades and the smoothness of the ice do away with friction

An amusing story is told of a small boy who wanted to help his mother by oiling her sewing-machine. He put oil on the large wheel over which the belt runs, with the result that he so reduced friction that when his mother tried to work the machine the belt slipped round the wheel without turning it instead of getting a grip and rotating it.

We get much the same thing when we travel on roller skates over a smooth floor, only in this case any friction between the rollers and the ground is rolling friction, and not sliding friction. Rolling friction is much less pronounced than sliding friction, and so great speeds can be obtained on roller skates.

But here is a paradox: it would be difficult, if not impossible, to travel with roller skates over ice, for there must be a certain amount of friction to give the necessary grip to the rollers to enable them to turn

It is difficult to walk on smooth ice, or even on the pavement when it has a coating of ice, such as it gets if the snow begins to thaw and then a frost suddenly follows. The reason is that the sheet of ice being so smooth, friction between our shoes and the surface almost disappears, and so our feet cannot get a grip of the ice

STRANGE HAPPENINGS IF FRICTION CEASED

Friction plays a very important part in our daily lives, and we read a good deal about this on pages 201 to 203. If there were no friction there are many things which we do now with ease which would be absolutely impossible. Friction is necessary to us, and yet in many directions, as in the working of machinery, we try as far as possible to overcome friction. On these pages a number of pictures show incidents in everyday life that could not be carried out if friction suddenly ceased. The pictures explain themselves. Every time we walked, for example, instead of the foot we put forward gripping the ground, it would slip back, and we could not get forward at all. All the actions shown depend for their success almost entirely upon friction

MARVELS OF INSTANTANEOUS PHOTOGRAPHY

Here is a description of a wonderful device by which miniature flashes of lightning more brilliant than the sunshine can be produced and regulated, so as to enable objects moving as fast as a bullet to be photographed with exposures of 1/500,000th of a second

When we realise that photography is little more than a century old, it is really marvellous to think of the amazing advances and improvements that have been made since Louis Daguerre of France first announced the production of photographs in January, 1839. Of course, he had been at work for some years before this, partly on his own and partly in collaboration with Joseph Nièpce.

At the same time, in England, Fox Talbot had hit upon the idea of making pictures by using the Sun's action on a chemical substance, and in the same year that Daguerre announced his invention of the daguerreotype, Fox published an account of his method of producing a negative plate; that is, one in which the lights and shades were reversed, and from which any number of positive copies could be obtained, pictures which were christened talbotypes, after their inventor.

By Daguerre's method each particular copy of a photograph had to be made afresh by the camera, whereas by Talbot's plan the negative plate enabled any number of prints to be made from it.

It must be pointed out, however, that, like so many other inventions, photography was not the work of one man, and long before Daguerre or Nièpce or Talbot had started their experiments, Thomas Wedgwood, a son of the famous English potter, Josiah Wedgwood, coated paper and white leather with a solution of silver salts and, laying opaque objects on the surface and exposing the fabrics to light, obtained imprints of the objects. The paper, where exposed, was turned black by the light, but remained white where it was protected from the light by the objects.

Later, Wedgwood, in conjunction with Sir Humphry Davy, continued the experiments and copied paintings on glass by placing them in contact with a sensitised surface. These copies, however, were not permanent, and the light soon darkened them till the whole paper became black. Apparently, neither Wedgwood nor Davy considered the invention of much importance, for neither seems to have tried to devise any method of making the photographs permanent.

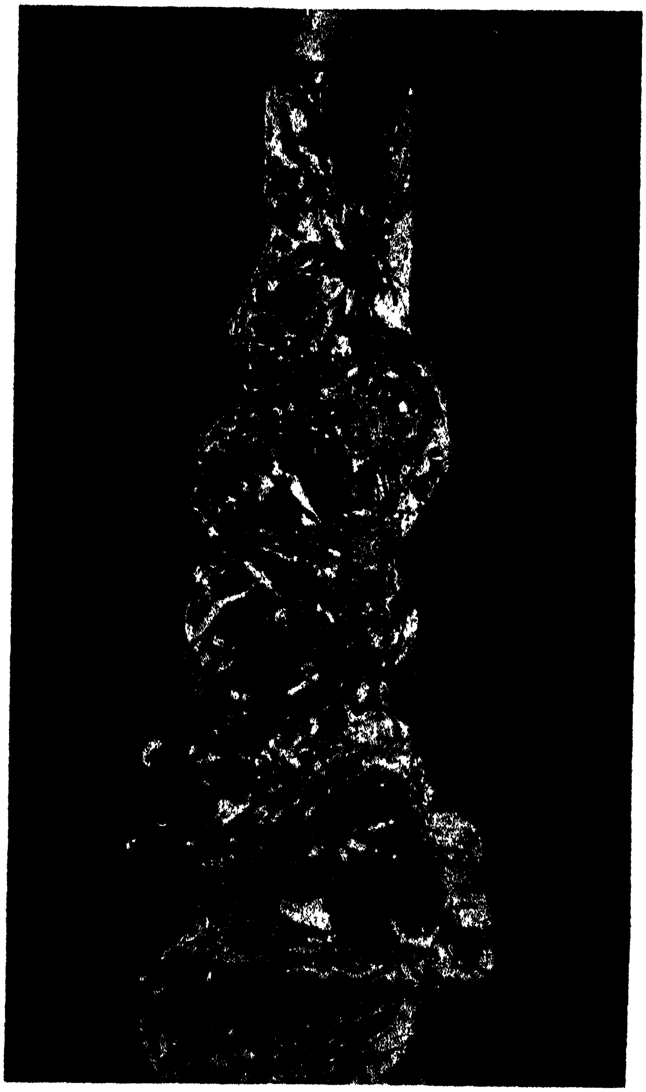
It is said that similar experiments had been carried out still earlier on the Continent, but, so far as authentic details go, we may call Wedgwood the first photographer.

Talbot, in a book on photography published in 1844, says: "When the Sun shines small portraits can be obtained by my process in one or two seconds, but large portraits require a

This is the apparatus by means of which photographs can be taken with exposures of one 500,000th of a second. The electrical device produces brilliant flashes of light that keep time with the exposure of the film in the camera. The light is brighter than sunshine

somewhat longer time. When the weather is dark and cloudy a corresponding allowance is necessary, and a greater demand is made upon the patience of the sitter.

"Groups of figures take no longer time to obtain than single figures would require . . . If we proceed to the City and attempt to take a picture of the moving multitude we fail, for in a small fraction of a second they



Here are two amazing photographs each taken in the 500,000th of a second. On the left we see an electric light bulb being broken with a hammer, and we notice that while the hammer smashes the top of the bulb, contact with the ground smashes the bottom. On the right is a stream of water issuing from a tap. The shape of the stream as it rushes from the tap is as clearly seen as if it were carved out of glass. These photographs and that on page 865 are given by courtesy of the Massachusetts Institute of Technology

change their positions so much as to destroy the distinctness of the representation."

But although Talbot speaks of photographs being taken in one or two seconds, it was a very different business in the studio. Having one's photograph taken eighty years or so ago was, indeed, an ordeal. The photographer painted the sitter's face white, because, as he informed his customer the flesh did not reflect sufficient light to affect the chemicals.

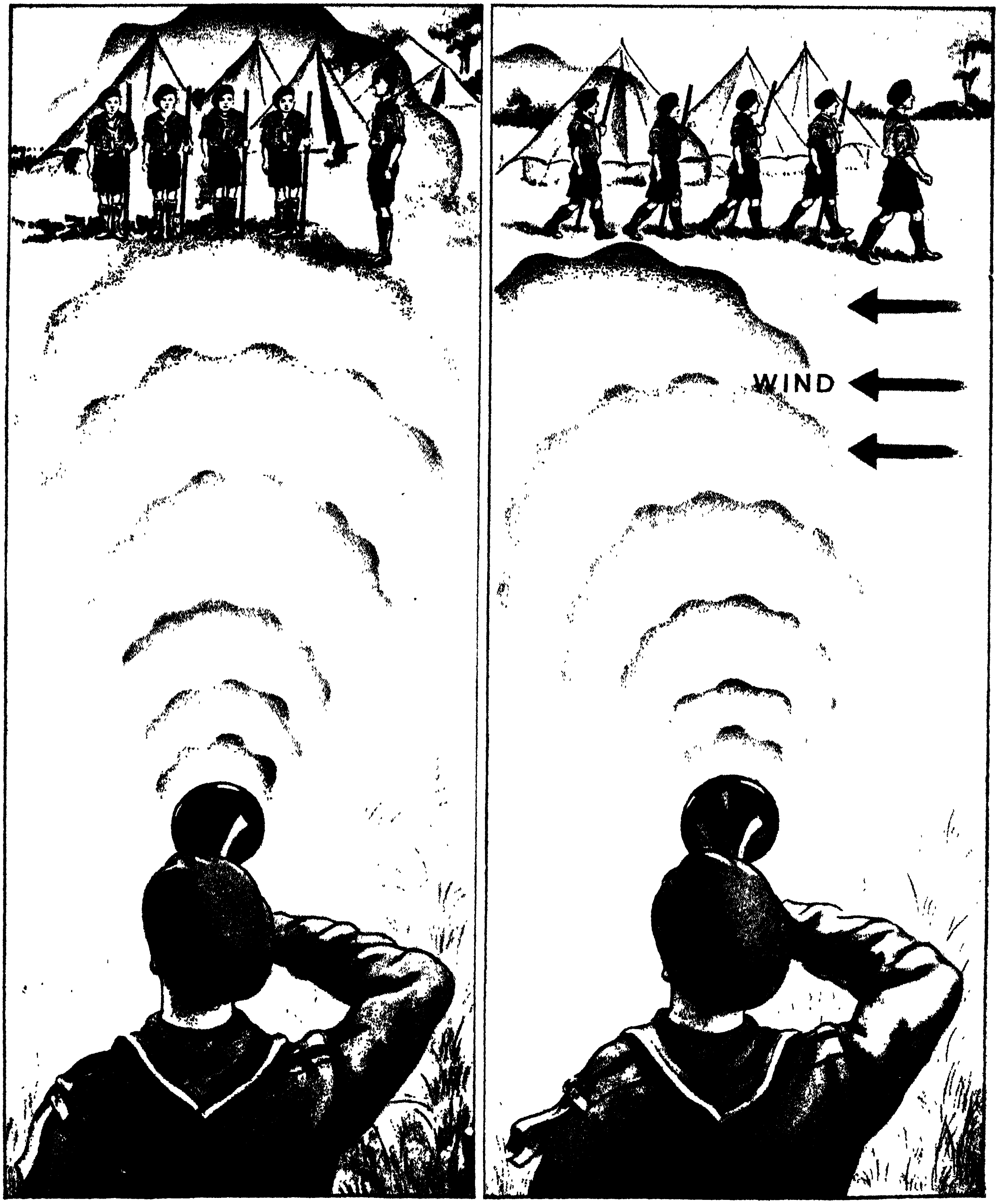
Even after this preparation the sitter had to remain perfectly still for about twenty minutes, with the back of his head fixed in a vice to prevent him from moving and spoiling the photograph. Then the full sunlight had to be reflected on the face, the sitter keeping his eyes closed.

All this has now been changed, and even a boy or girl with a camera costing a few shillings can take an excellent instantaneous photograph of a moving object.

Of recent years the speeding up of instantaneous photography has advanced by leaps and bounds. We have already seen on page 594 some remarkable photographs taken of a golf ball during play with an exposure of only one 50,000th of a second. On this page are given two other amazing photographs taken with the same speed. With the apparatus shown in page 866 light more brilliant than sunlight is produced by an electric circuit in pulses or flashes. The flashing of the light is made to keep pace with the speed of the film, and four thousand photographs a second can be taken with exposures of one half-millionth of a second. The light is equivalent to 40,000 fifty-watt bulbs

By using a photo-electric cell a bullet can be made to take its own photograph as it leaves a rifle barrel. The beam from the cell is projected across the flight-path of the bullet, and as the bullet passes it breaks the beam, whereupon an electronic device opens and closes the camera shutter in the split fraction of a second.

HOW THE WIND INTERFERES WITH SOUND



The distance to which sounds can travel in the open air and the clearness with which they can be heard depend largely on whether the day is calm or windy, and if it is windy, upon the direction and force of the wind. Naturally sound can be heard at a greater distance when travelling with the wind than when the wind is blowing from the listener towards the sound. Sounds are heard best, however, when the weather is calm. Even the slightest wind affects the intensity with which a sound is heard. In a wind the sound waves are scattered and the consequent scattering of their energy decreases the intensity of the sound. These two pictures explain this. In the first picture we see how the sounds of a bugle note travel in unbroken waves on a calm day, and on the right how the sound waves are broken up and scattered when the wind is blowing

THE MYSTERY OF THE ZONES OF SILENCE

There are many curious things about sound. It is transmitted by waves in the air, or in whatever substance it may pass through. But in its journey it is affected by many conditions, such as temperature, wind, and so on. Here we read some interesting facts about sound and how it travels from its source to our ear

The distance at which sounds can be heard varies a great deal according to the conditions of the atmosphere. If the day is quite clear and practically no wind is blowing a normal man's voice may be heard for several miles, provided, of course, that nothing intervenes between the speaker and the listener. If, however, the wind is blowing, the range of sound is greatly reduced. Even a light wind makes all the difference.

Naturally a sound can be heard at a far greater distance when it is travelling with the wind than when the wind is blowing from the listener towards the speaker.

A wind dissipates or scatters the force of the sound waves so that some of their energy instead of moving forward spreads to the sides. This scattering of energy decreases the intensity of a sound more than would be the case if there were no wind. As scientists put it "the intensity of sound decreases inversely as the square of the distance," which simply means that if you double the distance the sound is not half as strong but only a quarter, and similarly, if you halve the distance the sound is not twice as powerful but four times. Thus, if for example, a whistle can be heard for a distance of half a mile, four whistles in a calm would be heard for a distance of a mile. In a moderate wind, however, the actual distance over which the four whistles would be heard would be increased to only about three-quarters of a mile, instead of a mile as in a calm.

At night sounds can be heard much more clearly and over greater distances than during the day. This is due to the fact that the ear is more sensitive to individual sounds because there are fewer sounds disturbing the atmosphere. In addition, owing to differences in temperature, the sound waves are bent downwards and are thus able to reach the ear more easily. On a calm night the distance over which a sound can be heard may be as much as from ten to twenty times as great as during the day.

A Strange Thing About Sound

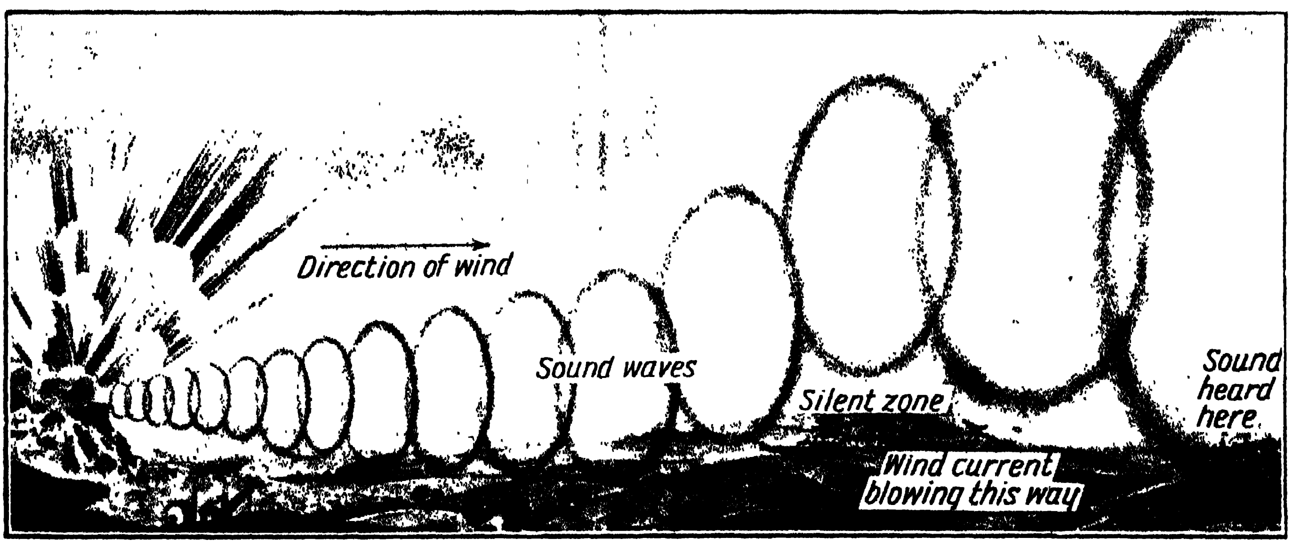
One strange thing about sound is that between the source of a sound and the outside distance at which it can be heard there is sometimes an area where the sound cannot be heard at all. This occurred in the great Silvertown explosion during the 1914–1918 War. It was heard as far north as Nottingham, Lincoln and Norwich, but could not be heard over a belt which included Ipswich, Lilford and Uppingham. Yet nearer still, at places like Northampton and Luton, it was heard distinctly.

The cause of these belts of silence is not yet understood. In some cases it is thought to be due to a reversal in the direction of the wind in the upper part of the atmosphere. The sound waves, it is said, are carried up and are then bent down again towards the Earth at a point some distance away, leaving a silent area in between. The explanation may be true in some cases, but there are many instances on record where areas of silence have occurred and the conditions have not been such as to justify this explanation.

Sound is carried rather better in a fog than in a clear atmosphere, although many people have the idea that fog muffles sound.

It must be remembered that when we speak of sound travelling in waves, though the waves are in the material through which the sound travels, whether it be air or a liquid, or solid, the particles of the material do not move along with the sound. The passage of sound is not like the flight of a rifle bullet. It is really the same kind of thing as when we hold one end of a rope which is attached to a post some distance away, and then by giving the rope an up-and-down motion we transmit waves from the end we are holding to the other end. The waves pass along the rope, but the particles of the rope do not travel towards the post.

The particles of air through which a sound travels have a motion something like that of the waves of the sea, as shown on page 210; that is, the movement of each particle is limited. This movement is very small, and is really alternately backwards and forwards



This picture gives one explanation of why a loud sound such as that which is caused by an explosion is heard, and then, after passing over a zone of silence, is heard again farther away. The matter is somewhat of a mystery, but it is believed that air currents have something to do with it, and that the sound waves are driven up into the air, and then return to the surface of the Earth

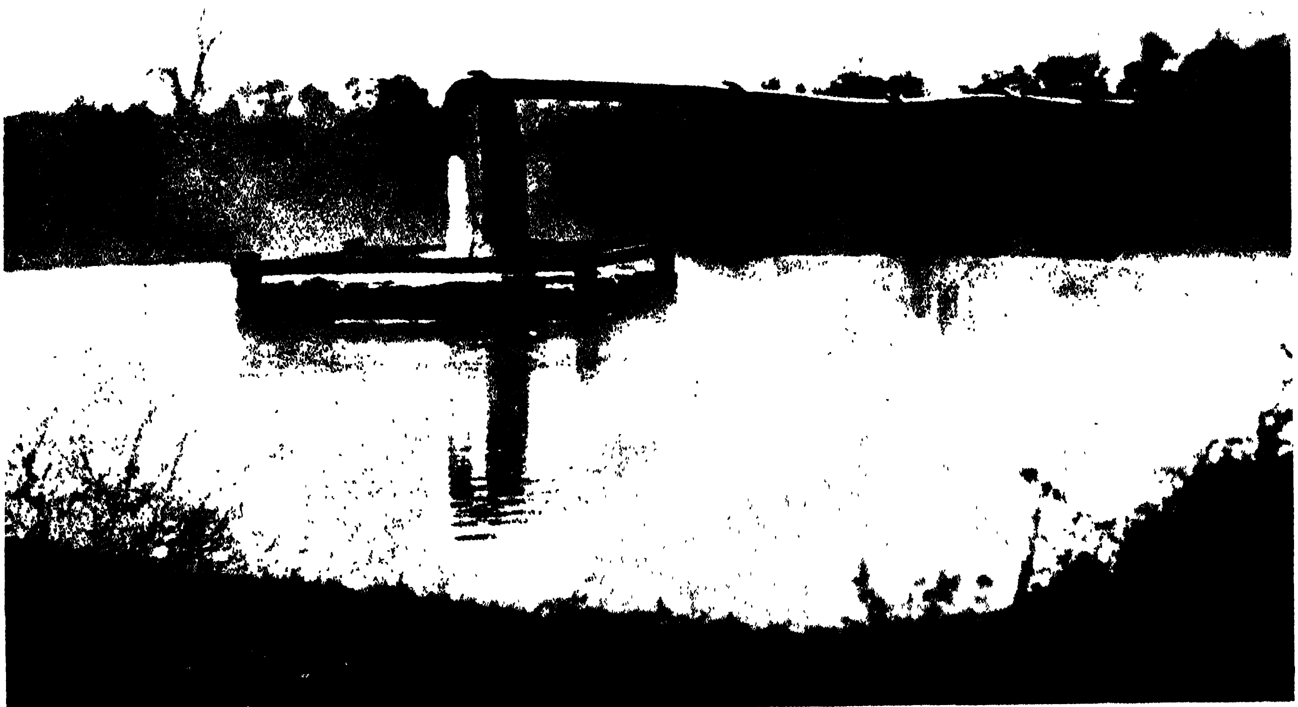
WATERFALL THREE TIMES HIGHER THAN NIAGARA

Waterfalls are not always caused in the same way. Sometimes the bed of a river is of unequal hardness, and the less resistant parts are worn away more rapidly than the harder rock up-stream, with the result that a precipice is formed over which the river pours. This is the commonest way in which falls originate. At other times a landslide or earthquake or flow of lava may form a dam over which the water flows. But whatever the original cause the falls are constantly undergoing change. Niagara, for example, is moving slowly up-stream, and that is the case also with these lofty Nevada Falls in the Yosemite Valley, U.S.A., which have a sheer drop of 594 feet

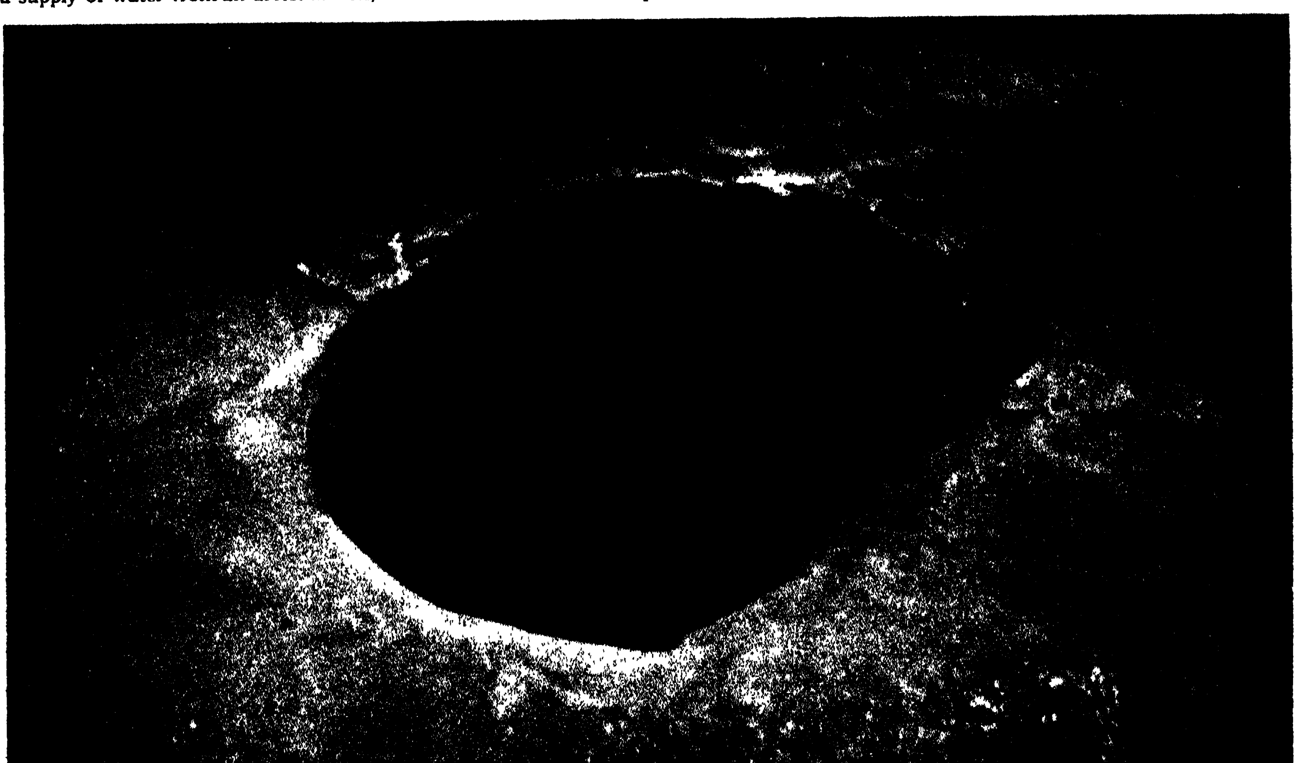
THE GREATEST MOUNTAIN RANGE IN THE WORLD

Which is the world's greatest mountain range ? Many people would say the Himalayas, because of the enormous height of many of the peaks. Others might answer the Andes, because of their great length. But the greatest mountain range in the world is neither of these. It lies where no human eye has ever seen it, except for one or two of its highest peaks. It is buried beneath the Atlantic Ocean, and runs from Iceland in the north to the borders of Antarctica in the south. Rising from the lowest plains of the ocean bed, it towers up in some places to a height of nearly four miles, and in a few places the lofty peaks rise above the surface of the ocean, as at the Azores, the Cape Verde Islands, Ascension, St. Helena and Tristan da Cunha. This mighty range is ten times as long as the Himalayan chain, and is known to geographers as the Mid-Atlantic Rise. Some people have tried to identify it with the lost continent of Atlantis, of whose fame and terrible, if legendary, fate we read in the classics

HOW AUSTRALIA IS ABLE TO GET WATER



Australia is of course a well-watered country so far as a wide area round its coast is concerned. But there are large tracts of country where rain rarely falls, and where there are no rivers or lakes on the surface of the land. Everywhere, however, in Australia there seems to be an adequate supply of water underground, and it is by sinking deep artesian wells that this water is tapped. Here we see a supply of water from an artesian well, which has been sunk so deep that the water is warm and steaming as it comes up to the surface



Sometimes the underground water in Australia is comparatively near the surface, and the natives dig water-holes in order to get at the life-giving fluid. One of these water-holes in the interior is seen in this photograph. It is really like a large surface well

CHANGING A PLANT FOE INTO A FRIEND

We have all heard of the prickly pear and what a pest it is in some parts of Australia. But the story of this plant, so strange in appearance is a real romance of science, and here the interesting record is told, and illustrated with striking photographs

In the sun-baked arid regions of America there grows a plant which has adapted itself to its unfavourable surroundings. Ordinary plants die in such regions for lack of water, for no matter how far they send their roots down, their leaves, warmed by the hot sunshine, give off more water than they can absorb, and the result is that they soon dry up and die

The prickly pear, however, which is called by botanists opuntia, has got over the difficulty in a very clever way. It has thickened its stems very much and reduced its leaves to mere spines or prickles, and in this way it has enormously reduced the surface which it presents to the sun and air.

It is only from the surface that water is given off by a plant, and so by reducing its surface the prickly pear is able to store up and save for its own use the water it collects. We can quite understand that an ordinary plant with many thin, wide leaves presents a very great surface to the air. Sir Arthur Shipley, the scientist, tells us of an elm tree which bore seven million leaves, whose surfaces added together amounted to about five acres.

A prickly pear, by thickening its stems and reducing its leaves to mere points, makes its surface about 300 times less for the amount of stuff in it than many ordinary plants. Experiments have shown the effect which this has on the amount of water which is lost. One square inch of the leaf of an ordinary plant, the aristolochia, gave off 5,000 times as much water as one square inch of a species of prickly pear.

Now the substance of the prickly pear makes a very good food for cattle and other animals, and the large amount of water which it contains means that it would be greatly sought after if it did not in a very ingenious way protect itself from attack. It does this in somewhat the same way that the British infantry at Waterloo protected themselves from the assaults of the French cavalry. They formed themselves into squares with their fixed bayonets held out before them on all sides The cavalry could make no impression on such a defence

When an ox or a rat or a mouse goes up to a prickly pear anxious to find food and water, it is met by an array of bayonets or pointed spines, and it cannot get through this defence, so it lets the plant live on in peace. Occasionally, a more daring animal with a tougher mouth will eat a prickly pear, just as an ostrich will swallow broken glass and rusty nails, or a goat will make a meal of old tin cans, but the animal suffers for its temerity and the spines generally lacerate its inside and kill it.

Where the plants grow close together the spines are a great obstacle to travellers, and we know how riders in these districts keep their feet and the upper part of their legs encased in thick leather stirrups, in order to protect them from the spines of the prickly pears. An American scientist, Dr. Veatch, tells us that once when he was journeying through San Felipe Pass his horse became irritated by the prickles of the plants and began to plunge about The traveller was thrown off and dragged through the plants until his clothes were, in his own words, "literally pinned to the flesh from head to foot by the barbed, needle-like prickles."

The prickly pear, showing the spines that protect it from cattle and other animals that would eat it

Up to a few years ago it was impossible to keep many cattle in the American desert lands, and this was very annoying to cattle owners, for as they could see there was an abundance of food and water in the prickly pears that thrived there But at the same time this good fare was so hedged around with protecting spines as to be almost unavailable Of course, when the cattle owners took the trouble to burn off the spines the prickly pear could be used for food and drink, but to do that in any quantity took time and was costly.

What could be done to overcome the difficulty? Well, America produced a man who thought a great deal about this. His name was Luther Burbank, and we read about him in another part of this book He did the most wonderful things with plants, changing their characters and creating new kinds of flowers and fruits, so that it is not without reason that he has been called the Plant Wizard.

He determined to breed a prickly pear which should have all its useful qualities but be free from the harmful spines, and he succeeded It was the most dramatic of all his triumphs, but it took him ten years of hard and patient work.

He started by selecting plants which had fewer or shorter spines than usual. He kept growing fresh plants from these getting the spines fewer and shorter each time, till at last on one great day, looking among the thousands of plants which he had growing in his grounds, he was delighted to find a prickly pear eight feet high, with the usual thick, fleshy stems, and not a single thorn upon it. Never had he had such a thrilling moment.

But he could not yet be sure that success had been achieved, for the plant might not breed true. His fears were groundless. The new plants he produced from this one all grew without spines, and gradually he multiplied them, till now tens of thousands of acres of dry wilderness in America

have great luscious crops of rich cattle food, where formerly nothing grew that was of use to man or beast.

As someone has said, Burbank at one stroke rid the world of a plant enemy and gave it a new plant friend. Not only does the spineless cactus or prickly pear provide abundant food for cattle, but its rich luscious fruits are a welcome food for man. The plant needs no rain, and before many years have passed millions of acres hitherto bare and uninhabited will probably be supporting vast herds of cattle and large populations of men.

Luther Burbank, the great plant wizard of America, who produced a prickly pear without spines, so that this could be grown in the arid regions of North America, and support thousands of cattle in country that had hitherto been desert. The prickly pear in its natural state is an excellent food, and contains much water, but its spines kill animals that swallow them

After his great achievement Burbank himself said :

" The population of the globe may be doubled, and yet in the immediate food of the cactus plant itself and in the food animals which may be raised upon it, there would still be enough for all "

But in Australia, to which the prickly pear was taken from America in the early years of the nineteenth century, the plant has become one of the greatest pests that island continent has to contend with. There it is among plants what the rabbit is among animal pests.

The plant was taken to Australia to serve as food for the cochineal insect, but it was nearly a century before it began to become a pest. Now it has spread over a large area of Queensland and New South Wales, the only two states in which the prickly pear is a real enemy.

Like the rabbit, which has multiplied into countless millions from two or three animals that were taken as pets to Australia, so the prickly pear in New South Wales has multiplied from one that was taken to that country in a pot because it was regarded as a rare and interesting plant. The prickly pear was found to make excellent hedges for keeping out animals, but it was not foreseen that it would spread and spread till it covered 35,000 square miles of territory, and invaded agricultural land.

All sorts of attempts were made to fight the pest, and stop its onrush into fresh territory, but no plan proved successful, and in 1920 a Commonwealth Prickly Pear Board was instituted to study the whole question. It was felt that if some insect could be found to prey upon the plant, then success might attend the great fight.

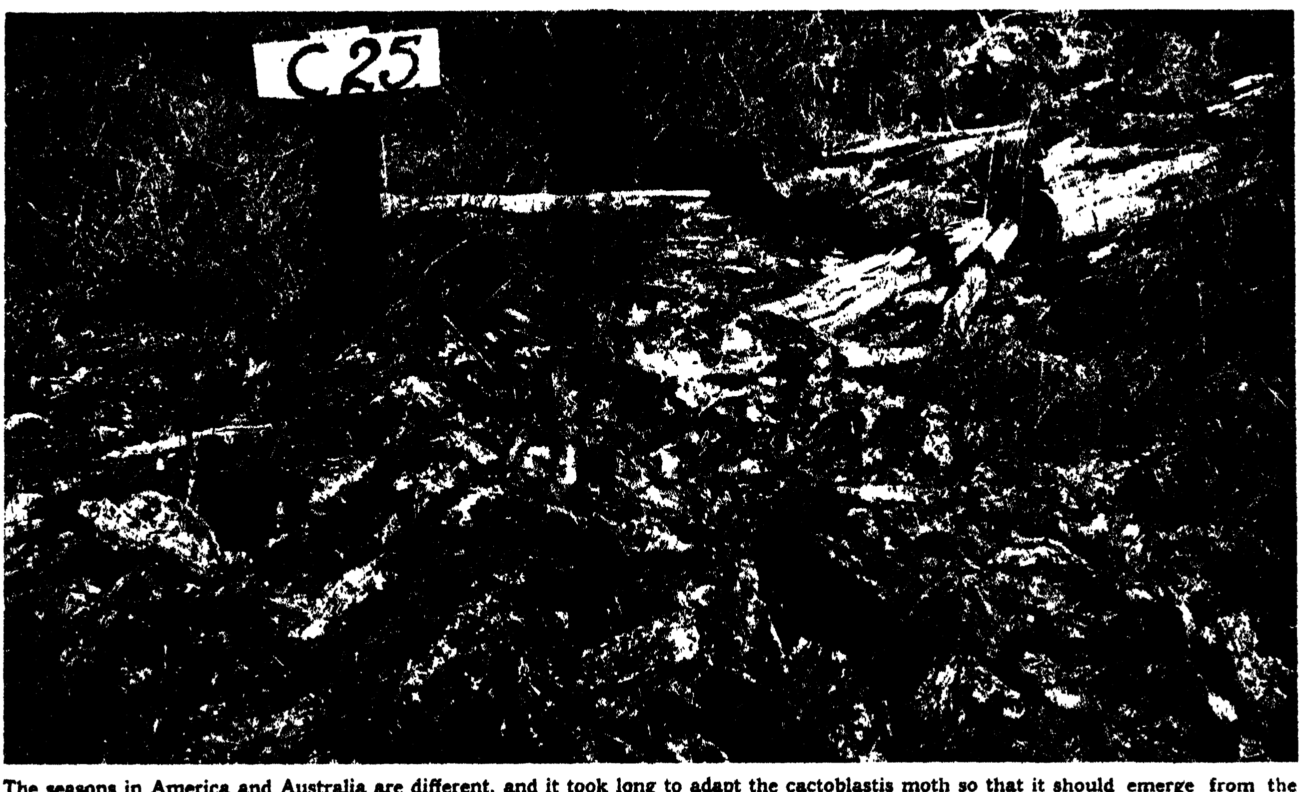
A number of insects that lived on the prickly pear were taken from North America to Australia in specially constructed cases, and then they were bred for several generations in order to insure that the moth which lays the eggs should emerge from the pupa stage at the right season, when the weather was favourable for its existence.

One of these insects, a moth known as the Cactoblastis cactorum, has proved a splendid ally in the war on the prickly pear. The moth lays it eggs in chains known as "egg-sticks," each stick containing about 75 eggs, and these are attached to the spines of the prickly pear. When the caterpillars hatch out they bore into the branches or "joints" and feed on the soft inner part, till the supply is exhausted. Then they attack a fresh branch. By the time the second generation has hatched out the cactus is a ruin, and how well the insects do their work can be seen by a comparison of the two photographs on page 875.

How necessary it was to find some insect aid in fighting the prickly pear in Australia is proved by the fact that a few years ago the pest was spreading at the rate of 800,000 acres a year. Already some three million acres once densely infested have been cleared.

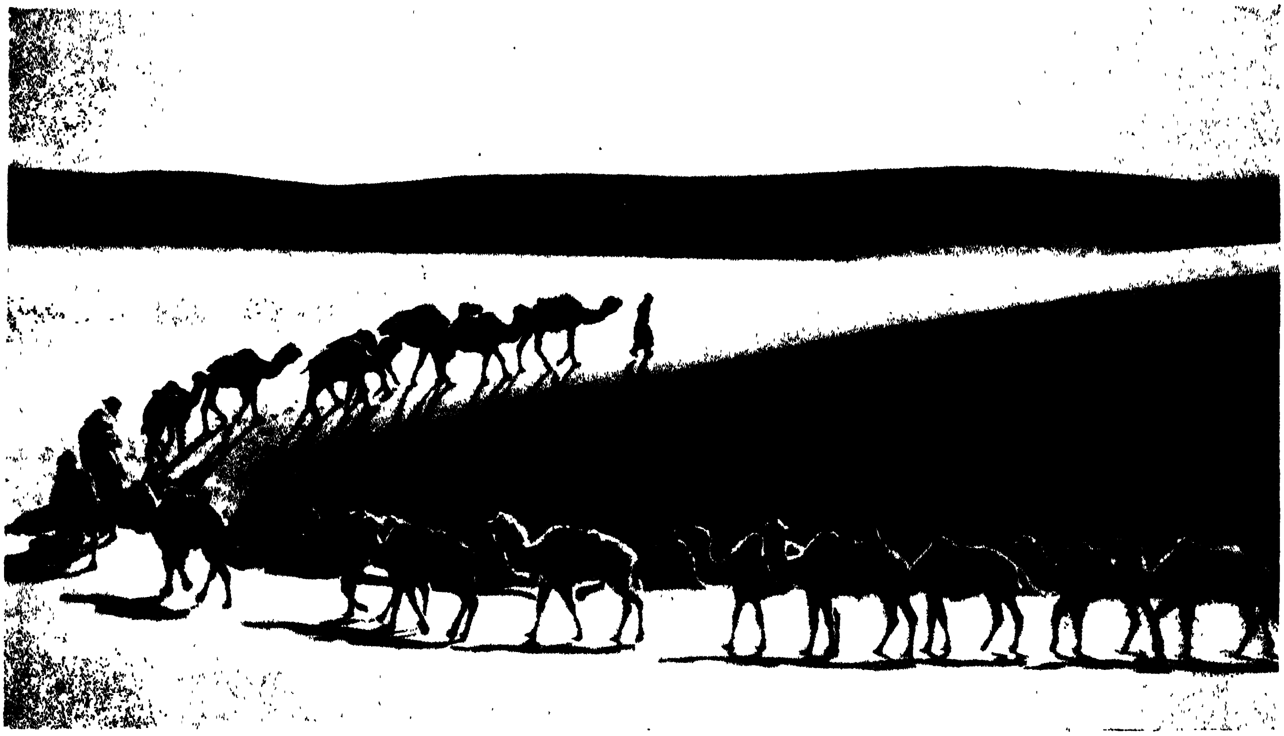
THE PRICKLY PEAR PEST BEATEN BY ITS ENEMY

The prickly pear, which is an American cactus, was introduced into Australia early in the nineteenth century as a food plant for cochineal insects. It spread, and by 1870 began to become a great pest in Queensland and New South Wales. It was planted for hedges, but soon covered thousands of square miles of territory, overrunning rich agricultural and grazing land. Many methods of fighting the pest were tried, but these all failed till a little moth, known as the cactoblastis, was introduced from America, and this is now helping to conquer the prickly pear Notice the long, sharp spines on these cactus plants

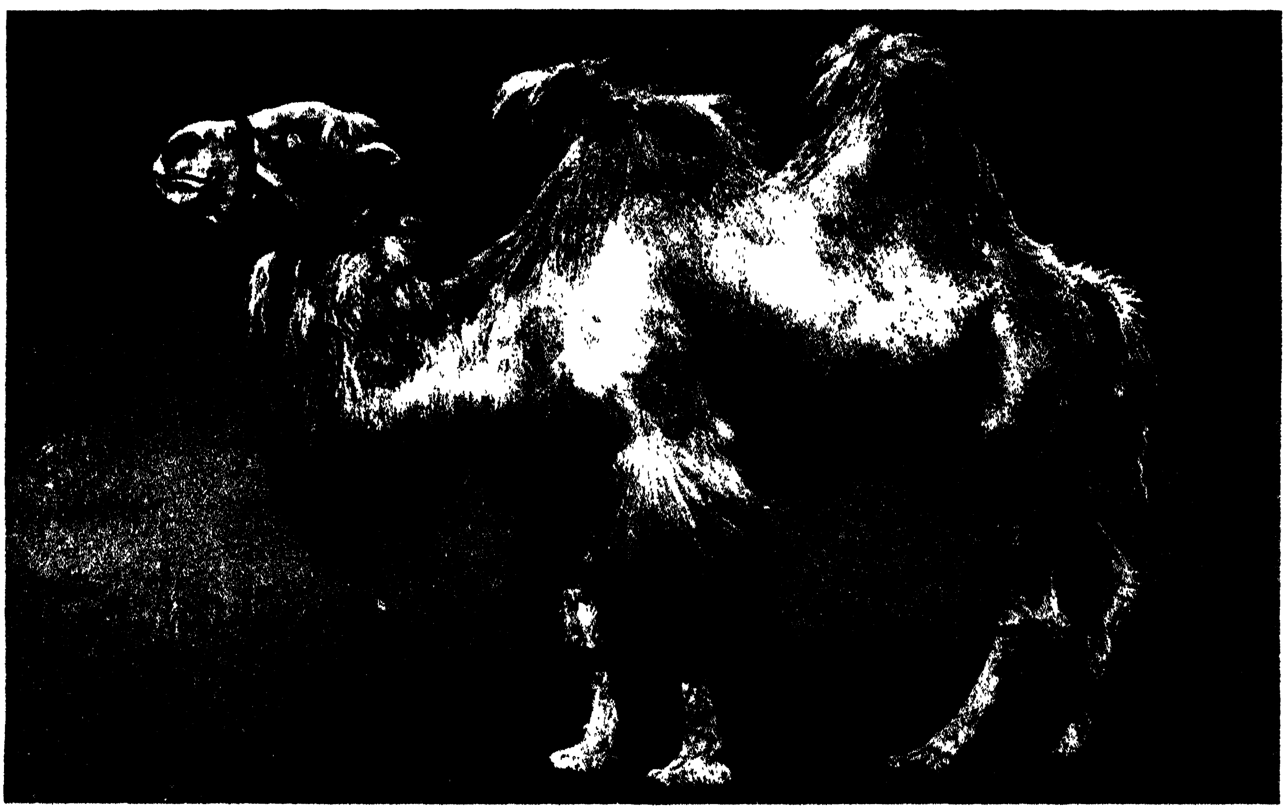


The seasons in America and Australia are different, and it took long to adapt the cactoblastis moth so that it should emerge from the pupa at the warm season when it could thrive and feed upon the prickly pear. How well it is doing its work can be seen by comparing the top photograph of a patch of prickly pear and this photograph of the same place after the cactoblastis caterpillars have been at work

THE HARDY TWO-HUMPED CAMEL OF ASIA



The camel of Asia, unlike that of Africa and Arabia shown on page 219, has two humps and a thick coat of hair. It is known as the Bactrian camel, from a province in the ancient Persian Empire, and lives in cold regions where snow lies on the ground. It is smaller than its Arabian relative, has shorter legs, and is more stoutly built. It is able to travel far and carry heavy burdens, and it can travel equally well over snow and sand. Here we see a caravan of Bactrian camels in the great Gobi Desert of Mongolia

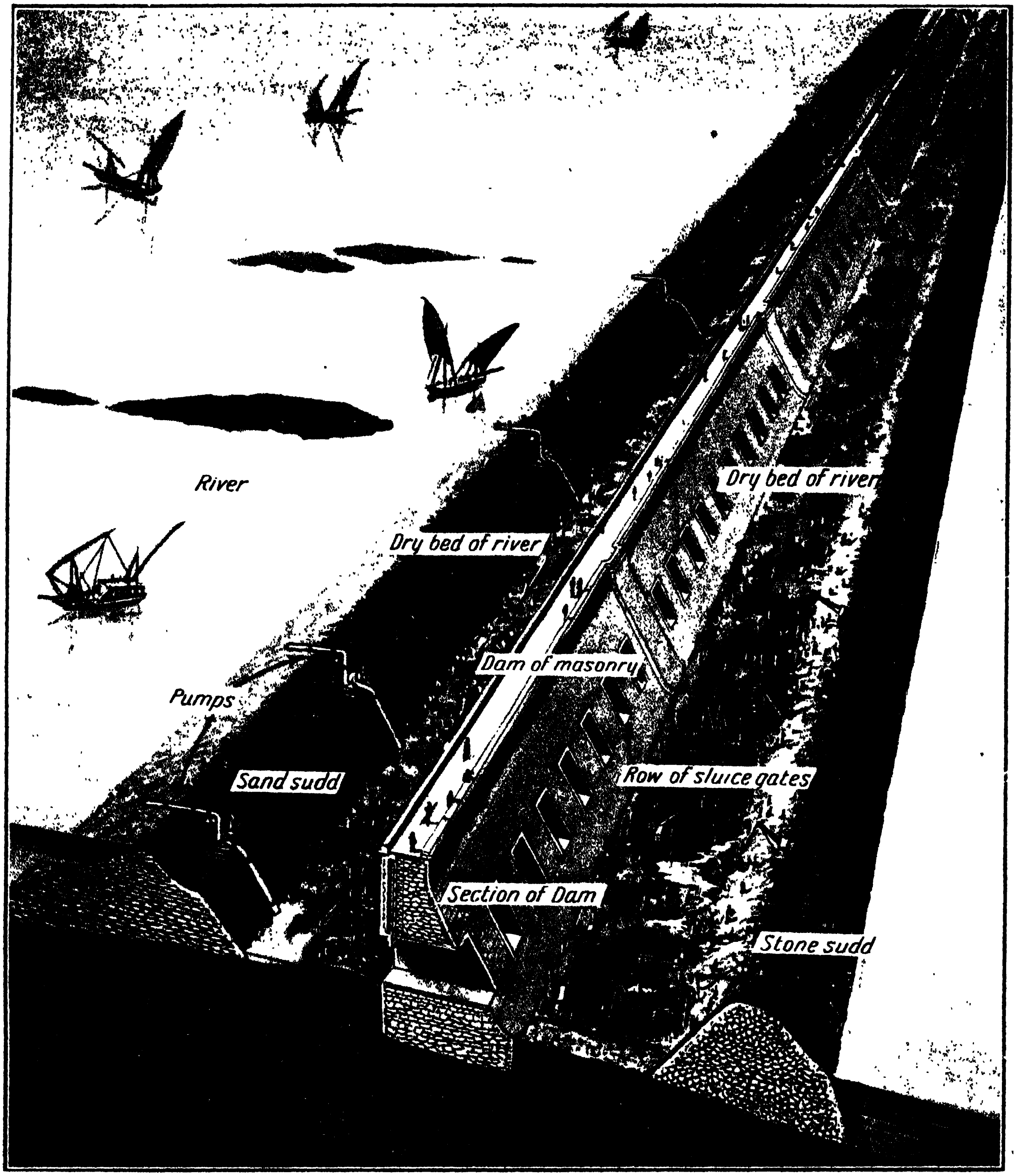


The Bactrian camel is a more picturesque-looking animal than its Arabian relative. In Spring it loses its hairy coat and becomes almost bare, when it is very sensitive to cold and rain, but soon the hair grows again. It is this warm covering that enables the camel to brave the severest frost. It seems to enjoy the biting north winds, and will even face these and breathe in the cold air as we breathe in the sea air when we are on holiday. When pressed by hunger the Bactrian camel will eat almost anything, including blankets and bones

ALL THE WORLD PROVIDES YOUR BREAKFAST

Have you ever thought when you sit down to breakfast that the whole world has been at work to provide you with the meal? In this picture the various foods and beverages that are used at breakfast are shown, together with the places from which they come. Of course, the countries shown are not the only ones that produce these particular foods. For instance, wheat may come from Australia or the Argentine; sugar may come from the West Indies and other places, and the butter may be produced in England. But what the picture makes clear is this: that hundreds of people have been at work in all parts of the world in order that people in Great Britain may enjoy the excellent breakfast which is now available for their consumption. Yet how little people appreciate the possession of so many luxuries. If we could see a breakfast-table of a hundred years ago we should better realise the great privilege which is ours to-day

MAKING THE GREAT DAM ACROSS THE NILE



This picture-diagram shows how the great dam across the Nile at Assouan was built. Before the foundations could be laid the bed of the river had to be rendered dry so that the workmen could carry out their task. The Nile is far too mighty a river to have its course diverted, so what could be done? The British engineers were equal to the problem. They built great temporary dams known as sudds across the river linking up the shore and the various islands, and then pumped out the water in between till the bed was dry. The down-stream sudd was built of stone, the great blocks of rock often weighing as much as four tons. But when the channel was almost closed even these blocks were carried away as though they had been corks, and railway trucks loaded with stone and wired round had to be hurled into the breach in order to stop up the channel. The up-stream dam was built up of bags of granite sand, dumped into the river. Of course a channel was left for the passage of boats up and down the river, for the Nile, in addition to providing water for drinking, washing and irrigation to the whole of Egypt, is also the great highway of the country. After the sudds were completed the permanent dam was then built up of masonry erected on a foundation of rough stonework, and that was built into the solid rock below. Since its completion the dam has been greatly increased in height and strength, adding to the area of irrigation

HOW A GREAT RIVER DAM IS BUILT

The British are the greatest masters of irrigation engineering in the world, and they have carried out some of the most gigantic schemes that the world has ever seen, as for example on the Nile and on the Indus River in India. Here we read something about these great irrigation schemes and how they were executed

IN different parts of the world during the last thirty or forty years some gigantic irrigation schemes have been carried out, and the most important of these have been planned and accomplished by British engineers.

The most recent of these to be put in operation is the harnessing of the Indus River at Sukkur in Sind, India. There a great dam known as the Lloyd Barrage has been built across the river for a mile, so as to form a vast reservoir of water which can be released as required for the irrigating of millions of acres of fertile land that needs only the life-giving water to make it produce vast quantities of food.

In building this great dam 90 million cubic feet of earth were excavated, over 720,000 feet of timber piles were driven into the river bed, 12 million cubic feet of masonry were used, and nearly three million cubic feet of concrete.

In addition to this work in connection with the barrage, the canals carrying the water for the irrigation of the land involved the excavation of 5,700 million cubic feet of earth.

A Great Boon

The total cost of this gigantic irrigation scheme was £15,000,000, but it was well worth it, for it is estimated that the crops of wheat, rice cotton, pulses and so on that will be grown as a result of the irrigation will amount to more than 2½ million tons a year.

Still another vast irrigation scheme designed and carried out by British engineers is that at Assouan on the River Nile in Egypt. Here is another huge dam a mile and a quarter long built across the river so as to hold up the flood waters when they come down and prevent them from running to waste. This is, of course, only part of the irrigation works of the Nile. There are other barrages, as at Esneh, Assiut, and in the delta of the river.

This harnessing of the Nile is one of the greatest triumphs in the history of engineering.

It might be wondered how when a great river is rushing away to the sea, a massive stone dam can be built right across its course, and the foundations laid so firmly that it can stand against the force of the water even in flood time.

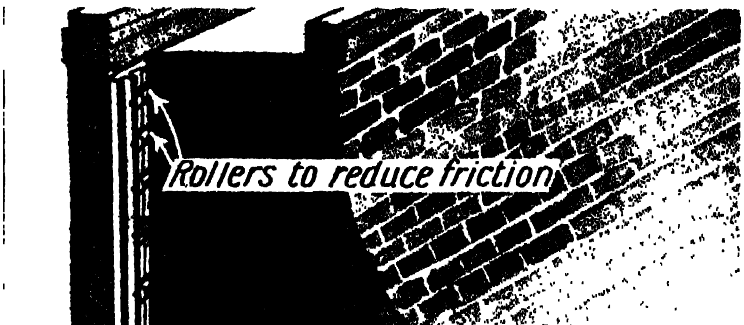
The method is to build what are known as sudds or temporary dams across the river, and then to pump out the water between these so that workmen can excavate and build the foundations and the superstructure of the dam.

This was dono in the case of the Nile, the sudds being constructed between the shore and various islands in the river. The down-stream sudd was first built, the material being tipped into the stream over the end of the sudd as it advanced.

When the down stream sudd had been completed an up-stream sudd was constructed. This was made of bags of granite sand. Then the water between the sudds was pumped out, and work could begin.

Gradually the permanent dam was built up, and the great sluice-gates, which had to resist a pressure of 300 tons, and yet be capable of being raised or lowered by hand, were placed in position.

The great dam was completed in 1902, but it has since had to be greatly increased in height, so as to hold up more water. Never was there such a successful irrigation scheme. A channel is left open for the passage of boats, the lock gates being worked by hydraulic power.



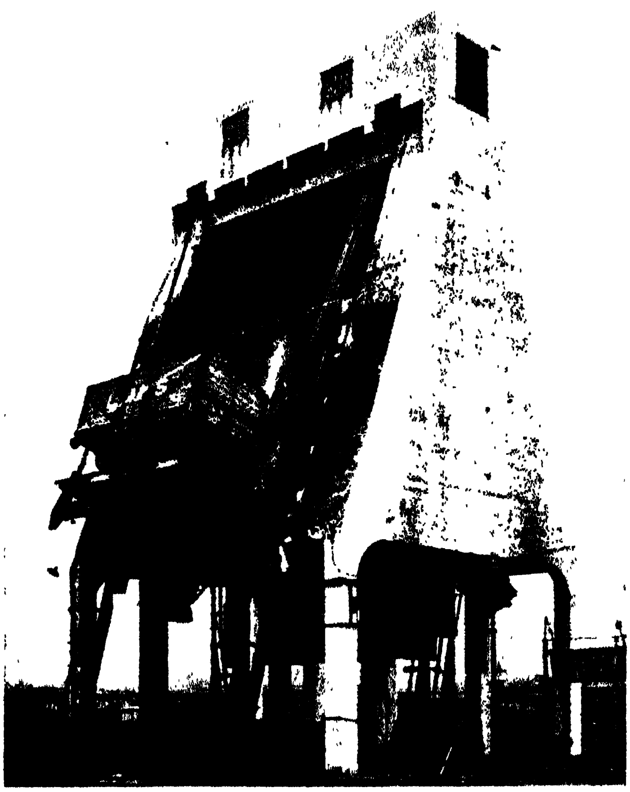
A section of the great Assouan dam on the Nile, showing a sluice and sluice gate. The gate, despite the enormous pressure against it, can be raised or lowered by hand. It works on rollers to reduce friction

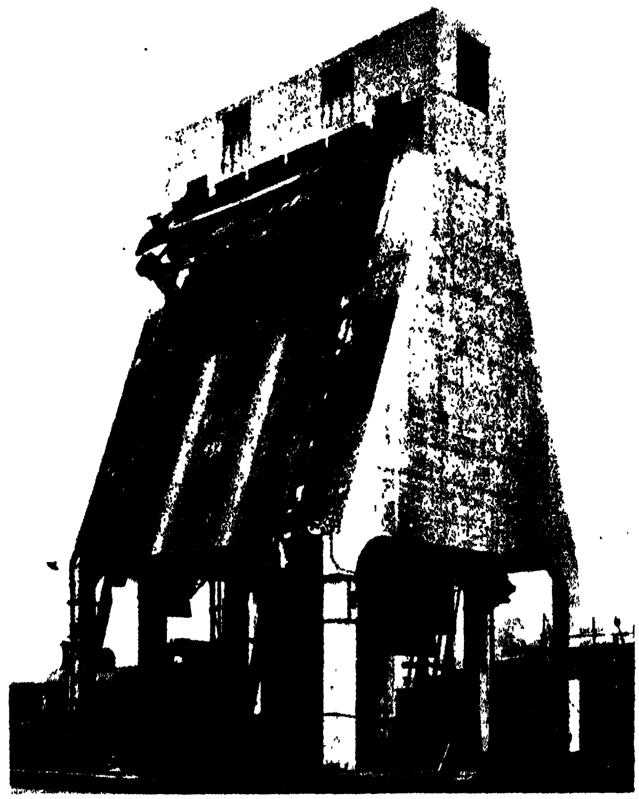
Building a Dam

In the case of the Sukkur barrage cofferdams were sunk round each year's area of operations. Then stakes were driven into the river bed, a bank of sand was deposited by dredgers to a little above the water level and the water was pumped out of the area, so that work could then go on. The next year another area was similarly enclosed, till at last the whole dam had been built.

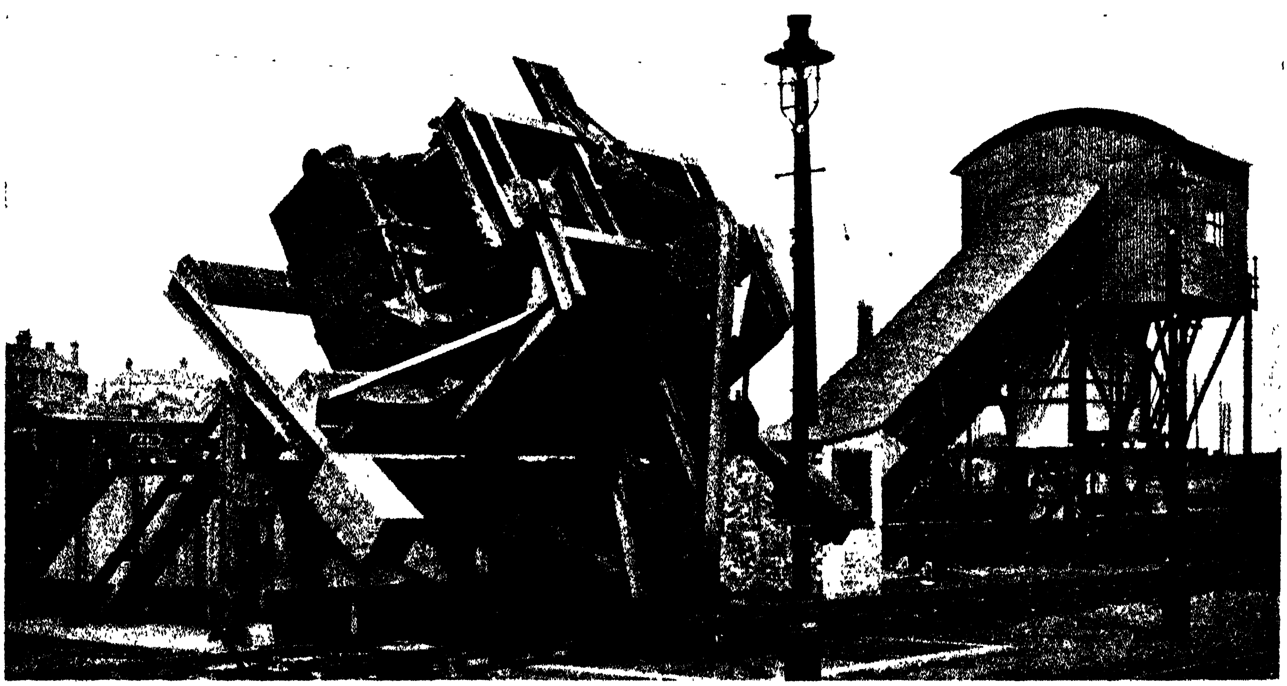
It is curious that in carrying out this great irrigation scheme both ancient and modern methods of excavation were adopted. There were 46 digging machines which removed earth at the rate of 74 tons a minute, while in another part the old-fashioned method was followed of scraping away the earth by driving bullocks. The two methods represented the old and the new India

HOW LOCOMOTIVES ARE SUPPLIED WITH COAL



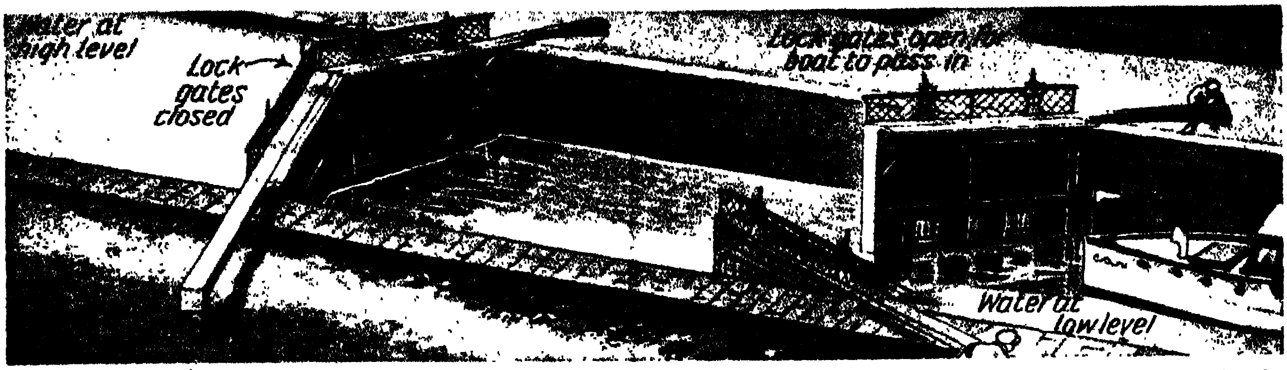


In the old days the coaling of a locomotive was a work which involved a good deal of labour and time, but wonderful improvements have been made in recent years, and nowadays a locomotive can be coaled by machinery in a moment or two. In this picture we see a type of coaling plant used in various parts of Great Britain. It consists of a tower with a platform below on which a truck of coal can be run. Then, by turning a switch the platform with the truck is carried up an incline to an opening at the top, where platform and truck are tilted and the coal shot into a bin. The truck is then sent down the incline again. When a locomotive is to be coaled it is run under the tower, and the touching of a switch fills the tender in a moment or two. The coaling tower in this picture is at Toton, on the Midland Region of British Railways. On the left the loaded coal truck can be seen going up, and on the right it is being tilted and the coal emptied out, while a locomotive beneath is being supplied with coal

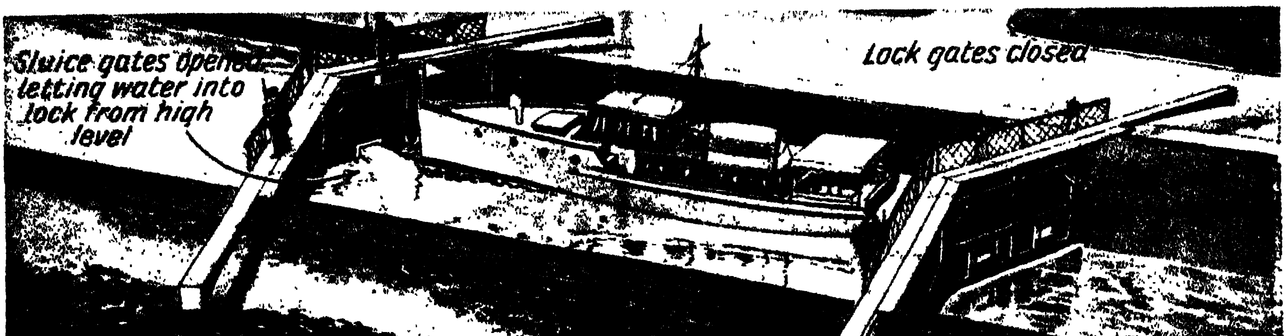


Here is another form of coaling plant on the Midland Region of British Railways, by whose courtesy the photographs on this page are given. It is at Wellingborough, in Northamptonshire. The wagon is run on to a tipper, and turned over so that the coal can fall out into a bin. Then an endless chain carries it up to a tower, from which it can be shot into the tender of a locomotive

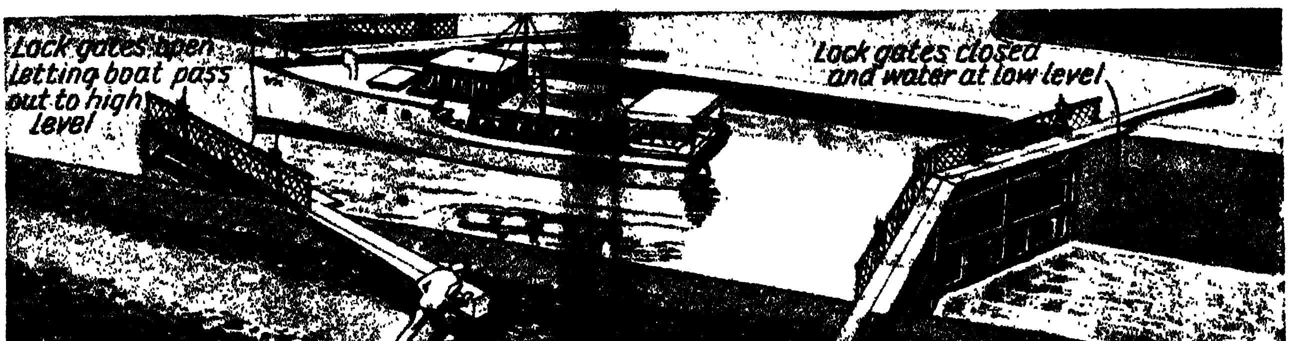
HOW A SHIP GOES UP AND DOWN STAIRS



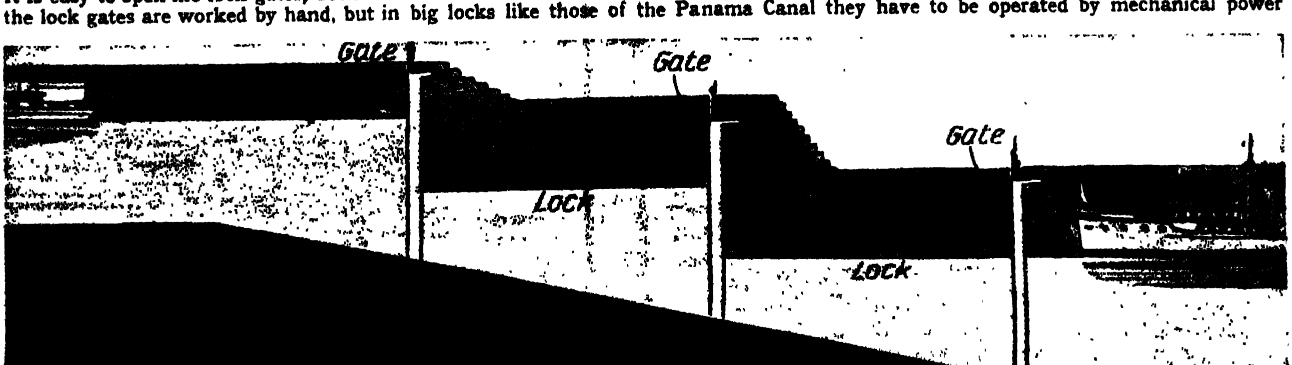
In many of our rivers and canals there is a great difference in level between the upper and lower reaches, and it is by means of locks that boats are able to go up or down between the different levels The pictures on this page show how the locks are operated. Here a boat is entering the lock from the lower level of the river, one pair of gates being opened to let it pass through



In this picture the boat has passed into the lock, and the lower gate is now closed to keep in the water. The sluices of the upper gate are being opened to allow water from the upper reach to flow in and raise the level in the lock to the higher level outside in order that the boat may then be able to pass out to the higher reach of the river. The sluices are operated by a wheel and ratchet



Sufficient water having passed into the lock to bring it to the higher level, the upper gates are then opened and the boat can pass out. It is easy to open the lock gates, because when the level is the same on both sides pressure is equalised. In small rivers and canals the lock gates are worked by hand, but in big locks like those of the Panama Canal they have to be operated by mechanical power



In some rivers and canals the gradient is very great, and ships go up and downstairs by a succession of locks, as shown here in section. The lock is really a very great invention, and makes possible a waterway between two oceans like the Atlantic and Pacific across such difficult country as the Isthmus of Panama. The world's biggest lock is that opened in 1928 between the North Sea and Amsterdam Ship Canal at Ymuiden. It is 1,312 feet long and 164 feet wide and is thus capable of accommodating the world's largest steamship

ROLLING OUT A WHITE-HOT INGOT OF STEEL

Steel of the best kind is an exceedingly hard metal. If it were not so we should not be able to make of steel the wonderful machines that we do, which will go on working for years often without signs of wear. Yet when steel is white-hot it is in a plastic state, and can be rolled out just as a housewife rolls out dough on the pastry-board with a rolling-pin. Here we see a white-hot steel ingot passing through the rollers in one of the great mills of the United Steel Company at Sheffield

The white-hot steel is rolled backwards and forwards until it is thinned out into long lengths. Here a snake-like length of steel is being transferred from one set of rollers to another for still further reduction. The workers who do this become very skilled, as is, of course, very necessary. These lengths of hot metal have to be handled with great care and discretion or serious accident would result

WONDERS of LAND & WATER

STRANGE FACTS ABOUT YOUR WEIGHT

You may not know that your weight varies according to the place where you are weighed. For instance, if you weighed seven stones in London, you would weigh more in Greenland and less in Uganda. You would also weigh less on top of Mount Everest than in the plains of India, and you would weigh less at the bottom of a mine than at the surface. Why this should be so is explained below

MEN of science tell us that the Earth on which we live weighs nearly six thousand million million million tons, and on pages 74 to 77 of this book we read of the clever ways in which they have weighed the Earth But instead of speaking of the Earth's "weight" the scientists call it "mass."

What is the difference between these two expressions? Well, mass is the amount of material in a body, whereas weight is the amount of pull that the Earth exerts on that body. Of course we measure mass by weight. For instance, if the Earth's attraction or pull on a body is equal to one pound, we say that there is one pound of matter in that body. We must remember this distinction between mass and weight, for while the mass of a body remains the same wherever it may be, the weight varies.

Suppose, for instance, a big man were weighed in London and found to be 16 stones. If he were suddenly transported to the surface of the planet Jupiter he would weigh 39 stones 9 pounds. His weight would have been more than doubled, but of course his mass, that is, the amount of material in his body, would remain the same.

But we need not go to Jupiter to find a change in weight. Anything weighed on the Equator would weigh less than it would in London, and anything weighed in London would weigh less at the North Pole, for at the Earth's surface or above it the nearer we get to the centre of the Earth the greater is the pull, and therefore the greater the weight. Seeing that the Earth is not a perfect ball, but is flattened by the Poles, it is clear that as we go nearer to the Poles we are at a less distance from the centre of the Earth than we are as we go nearer to the Equator.

It is equally true that at the top of Mount Everest we should weigh less than we do on the plains below, for on the mountain top we should be farther from the Earth's centre, and the pull of gravity would be less than when we stood on the lowlands.

This being so it might be supposed that when we went down a deep mine we should weigh still more there than when we stood on the surface of the ground. But this is not the case. We should weigh less when in the mine, as a new factor comes into play.

Although we should be nearer the centre of the Earth, the size of the sphere below our feet whose gravitation acted at the Earth's centre would be smaller than when we were at the surface, and so its pull would be less. The attraction of the particles in the Earth's crust above us, too, would result in a certain balancing of forces. If we could travel to the Earth's centre the forces would be so balanced that we should have no weight at all.

When we are walking in the fields or across a common, or even in the street of a city, the ground seems very still. It is impossible for us to realise that this ground is whirling round at a rate far greater than that of a jet-propelled aeroplane like the Comet

Of course the rate at which the ground whirls round varies according to the part of the world on which we are standing. At the Equator the Earth rushes round at over a thousand miles an hour, or 1,525 feet every second. As we get nearer the Poles the speed, of course, gets less.

Now why, with the Earth whirling round in this way, are we not all thrown off its surface into space? We see in another part of this book (pages 61 to 64) that the power of centrifugal force is very great. If we spin a flat horizontal top, for instance, and then drop grains of sand on to it, they are immediately whirled off. Yet we are not whirled off as the Earth rushes round. Well, the reason is that the power of gravitation, that is, the pull of the Earth, holds us to it.

It is gravitation that keeps us and the atmosphere from being thrown off into space; it is gravitation that gives weight to every material substance and body, and it is gravitation that enables us to measure easily and quickly the amount of matter in a body.

But centrifugal force tends to overcome the power of gravitation, and at

A man weighing 192 pounds at the North Pole would weigh only 191 pounds at the Equator The difference is due to the fact that at the Equator he is farther from the Earth's centre, where gravitation, or the Earth's pull, is acting, and partially to centrifugal force, owing to the increased speed of the Earth at the Equator, counteracting gravitation. Weights and scales are shown in the drawing, but for practical demonstration a spring balance would be used, as the difference in the pull of the Earth affects weight and men equally.

the Equator, where the centrifugal force is greatest, its results are most marked. It diminishes the weight of a body as compared with its weight at the Poles by one 289th. The loss of weight of a body at the Equator owing to its greater distance from the centre of the Earth is one 568th. Therefore the total loss of weight at the Equator compared with the Poles, owing to the difference in distance from the Earth's centre and the difference in centrifugal force owing to greater speed, is one 568th plus one 289th, which is equal to one 192nd. In other words, a body that weighed 192 pounds at the Poles would weigh only 191 pounds at the Equator.

Of course, gravitation is not confined to the Earth. The Sun's gravitation keeps the planets circling in their orbits; the gravitation or pull of Jupiter keeps his moons circling round him, just as the Earth's gravitation keeps our Moon in its course; Saturn's gravitation keeps his rings in position and prevents them from breaking up and rushing away into space.

Mr. H. G. Wells once wrote a story about a man who overcame the power of gravitation and as a result floated up to the ceiling. He could not get down to the floor again until a bright idea struck him. He had recently bought a large encyclopedia consisting of many volumes, and these were piled up one upon another. Seizing two of the volumes he was enabled to bring himself down to the floor safely, because the power of gravitation, which he himself had overcome, still worked in the case of the heavy books.

It was a fantastic and amusing story, and no doubt there would be certain advantages if men could overcome the power of gravitation in some cases. But, of course, it would also have great disadvantages.

For instance, when we were sitting at our breakfast, if in some wonderful way the power of gravitation could be removed from the plates and cups and saucers and other things on the table these would suddenly be whirled away by the power of centrifugal force.

If a mass of lead or any other substance which weighs a pound at the Equator be taken towards the Poles it weighs more, but the weight which we put into the other pan of the scale also weighs more, and so the beam of the scale remains horizontal.

How, then, can we tell that the mass of lead weighs more near the Pole? Well, we use a different kind of weighing machine. Instead of an ordinary pair of scales in which the object to be weighed is put in one pan and the weight in the other, we use a spring balance, in which the weight is determined by the pull on the spring; that is, the Earth's attraction pulls the object being weighed, so the object pulls the spring and the weight is recorded on a dial.

It is clear from this that the ordinary scales in which both the object weighed and the weights would change according to the part of the Earth in which they were used, is really a machine for measuring mass and not weight, whereas the spring balance measures the weight, or gravitational pull, and not the mass of a body.

THE MYSTERY OF THE WILL-O'-THE-WISP

We often hear and read of the Will-o'-the-Wisp which Milton refers to as "a wandering fire hovering and blazing with delusive light," which

> Misleads th' amazed night wanderer from his way
> To bogs and mires, and oft through pond and pool

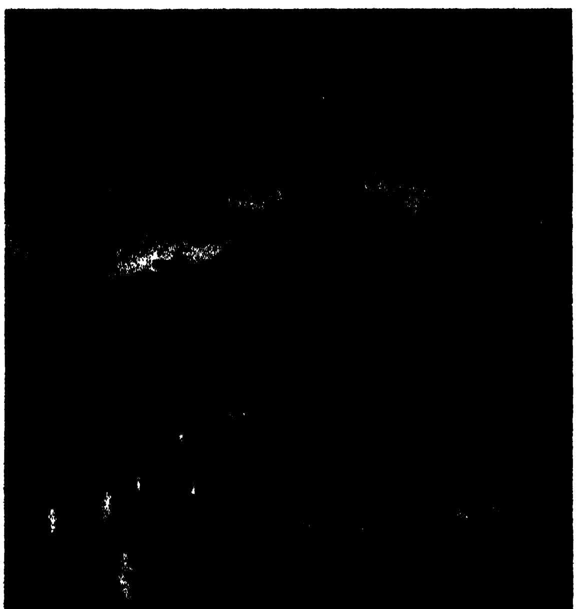
This queer phenomenon has many other popular names, such as Jack-o'-Lanthorn and Ignis Fatuus, which means "foolish fire." Many circumstantial stories are told about the dancing light in marshy districts which the traveller sees in the distance, and trying to follow it, is lured to his death in the swamp.

Scientists have written learnedly about the Will-o'-the-Wisp, declaring that it is caused by burning marsh gas or another gas known as phosphurotted hydrogen. Against this explanation is the fact that these gases do not catch light of themselves, and in any case the flame could not dance about as it is said to do.

The latest science explains the Will-o'-the-Wisp by saying that it is pure imagination, and has no real existence outside the mind of the one who is supposed to see it.

Professor Nathaniel Shaler has made a close study of the supposed phenomenon and the stories about it, and he says, "Looking fixedly into any darkness, such as is afforded by the depths of a wood, the eye is apt to imagine the appearance of faint lights. Those who have had to do with outpost duty in an army know how the anxious sentry, particularly if he is new to the soldier's trade, will often imagine that he sees lights before him. These facts make it seem probable that the Jack-o'-Lanthorn and his companion the Will-o'-the-Wisp are stories of the over-credulous."

Dr. Shaler points out that the explanation generally given about a self-inflamed gas is not based on fact, for a gas of any kind would disperse itself in air. It could not dance about as these lights are said to do, and there is no chemical means known whereby it could be produced in sufficient purity and quantity from the earth to yield the effects which are described.



The supposed lights that lure the night traveller

The descriptions of the Will-o'-the-Wisp that have been given vary so much that it is quite likely the cause of the apparition has been different in different cases. Sometimes, no doubt, it has been pure imagination, sometimes there has probably been an electrical appearance, while at other times it is quite likely that the dancing light has been that of a real lantern carried by someone in the distance, who disappeared before the traveller could come up with him.

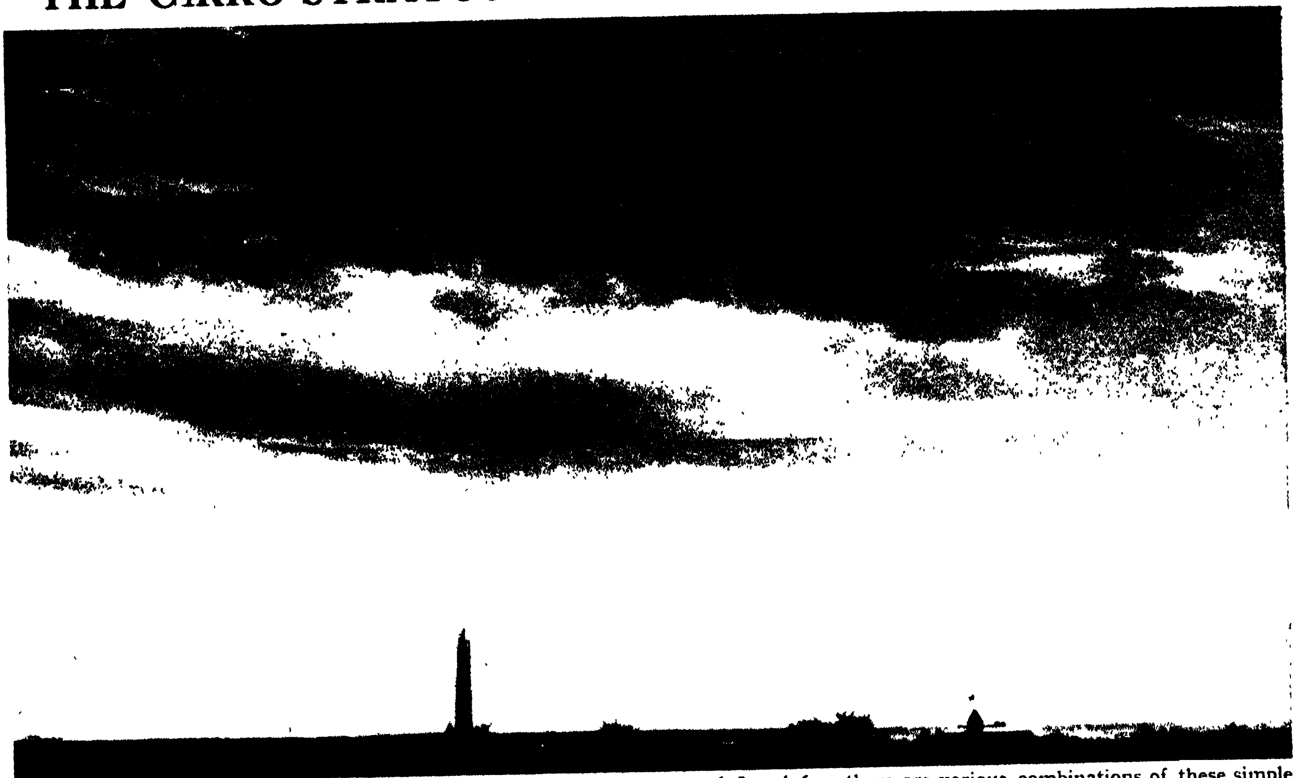
The picturesque description of the Will-o'-the Wisp often given, while suggesting the good faith of the narrator, is indicative of an imaginative rather than a scientific mind. Many people still believe in this phenomenon as they did in Shakespeare's time. That poet refers to it in "The Tempest" when he makes Stephano, after Ariel has led him and his companions through "tooth'd briers, sharp furzes, pricking goss and thorns," say: "Monster, your fairy, which you say is a harmless fairy, has done little better than played the Jack with us"

The Will-o'-the-Wisp said to have been seen at sea playing round the masts of ships is, of course, St. Elmo's fire, described on page 108.

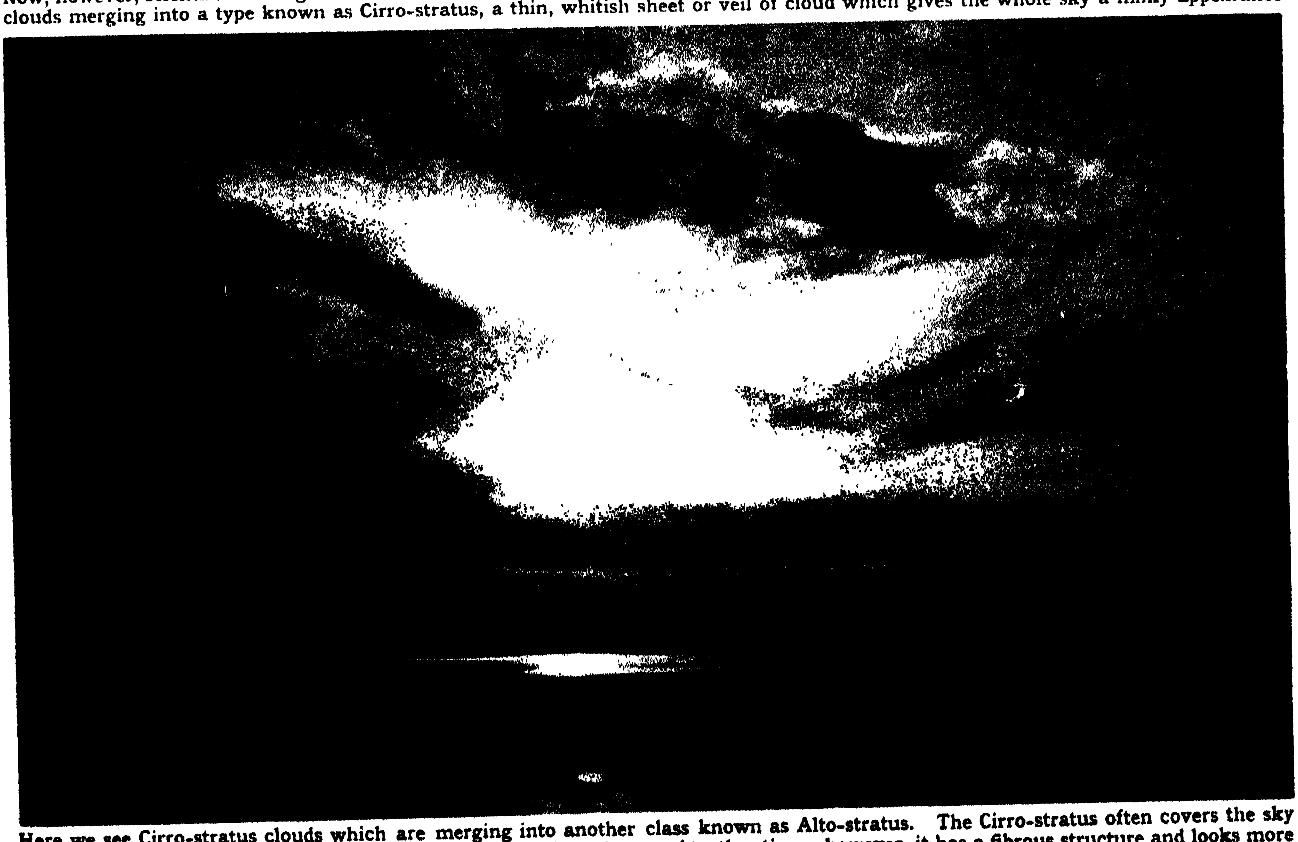
THE WATERS OF NIAGARA ABOVE AND BELOW

Here is a wonderful cloud effect photographed at Niagara Falls. Above in the sky we see masses of clouds which will soon pour down their rain upon the earth to sink through the ground and flow into the river. Later on the water will rush down its course and pour over the precipice as we see it doing in the lower part of the photograph. We see on page 255 the continual circulation of water that takes place to keep the Falls going. Over 670,000 tons of water are poured over the Falls every minute of the night and day. Originally the Falls stood at Queenston, some miles lower down the river, but gradually the water has worn away the rock and it is still doing so at an average of about a foot a year. The ravine between the present Falls and Queenston must have taken 30,000 years to excavate

THE CIRRO-STRATUS CLOUDS THAT CAUSE HALOES



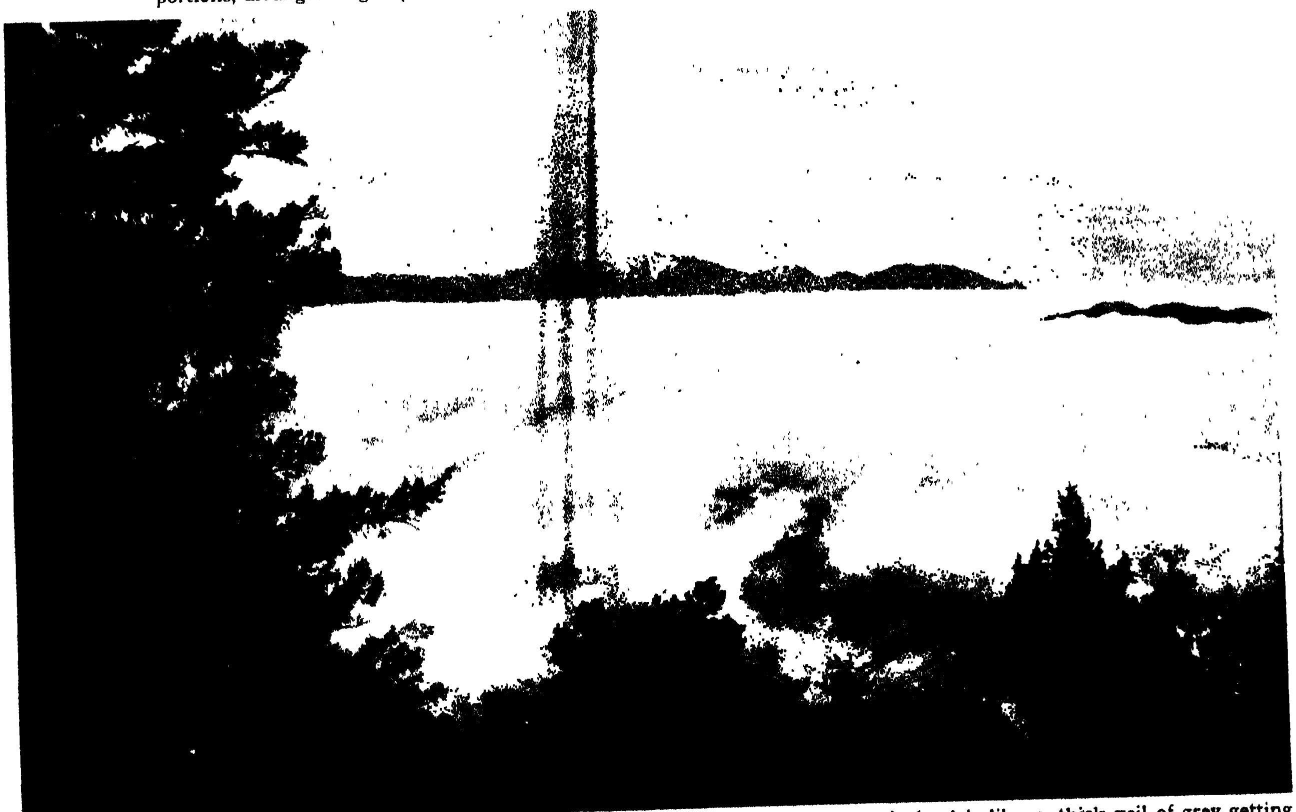
In addition to the four main classes of clouds which are shown on pages 628 and 629, there are various combinations of these simple forms. Of course, one variety merges into another, and in the old days very many names were given to different cloud appearances. Now, however, scientists have agreed to class them all under ten main types, thus simplifying the study of clouds. Here we see the Cirrus clouds merging into a type known as Cirro-stratus, a thin, whitish sheet or veil of cloud which gives the whole sky a milky appearance



Here we see Cirro-stratus clouds which are merging into another class known as Alto-stratus. The Cirro-stratus often covers the sky completely, when it is sometimes called Cirro-nebula or Cirrus haze. At other times, however, it has a fibrous structure and looks more or less like a tangled web. It is the Cirro-stratus cloud that produces those interesting phenomena known as solar and lunar haloes. Cirro-stratus clouds are never lower than 7,000 feet, and often 42,000 feet above the ground. Their mean height is about 22,000 feet

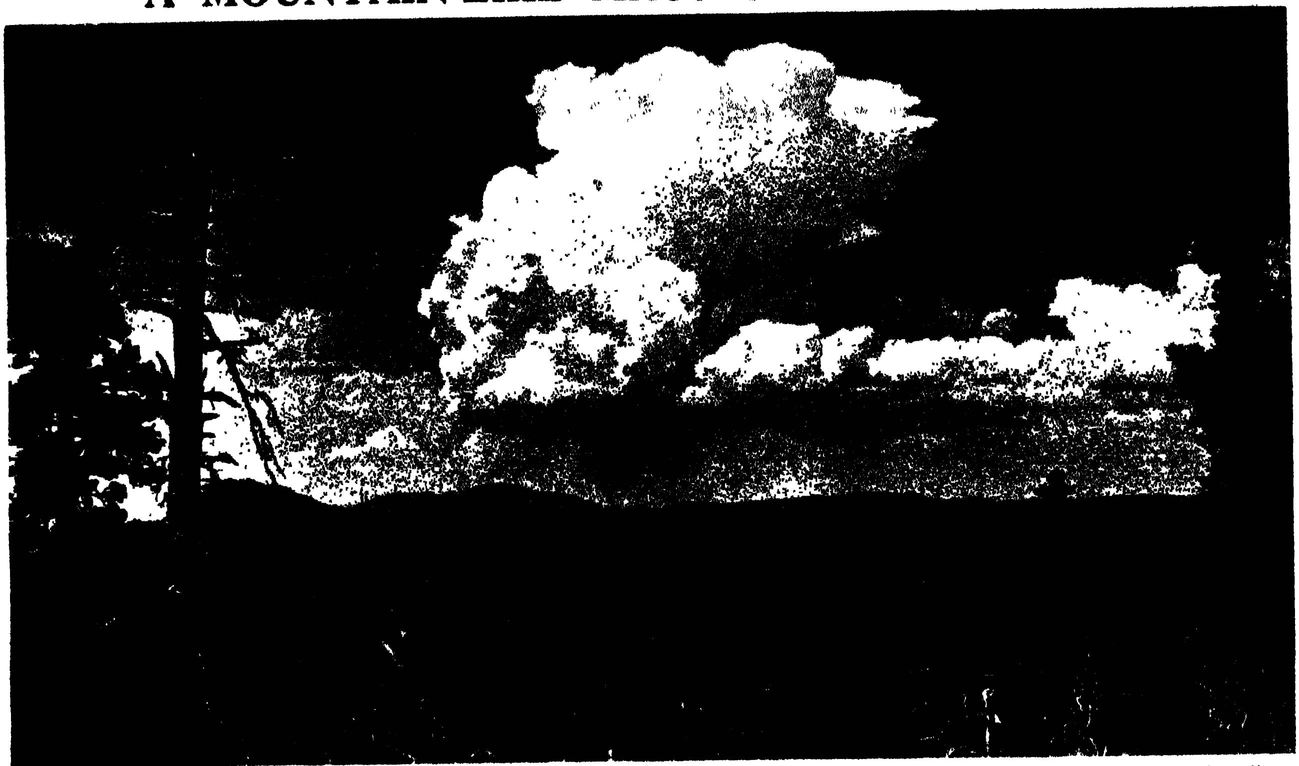
VARYING CLOUD FORMS AT DIFFERENT HEIGHTS

On the left we see Cirro-cumulus clouds which are small white balls or flakes of semi-transparent cloud with little or no shadow. They are arranged in groups and often in lines. They range in height from 7,000 feet to 35,000 feet, but their mean height is 20,000 feet. They form the well-known mackerel sky. On the right are small Alto-cumulus clouds, which vary in height between 2,700 feet and 27,000 feet, though their mean height is 12,000 feet. They are in the form of white or greyish balls of dense fleecy cloud, with shaded portions, arranged in groups or lines. Often the masses are so crowded together that the cloudlets join

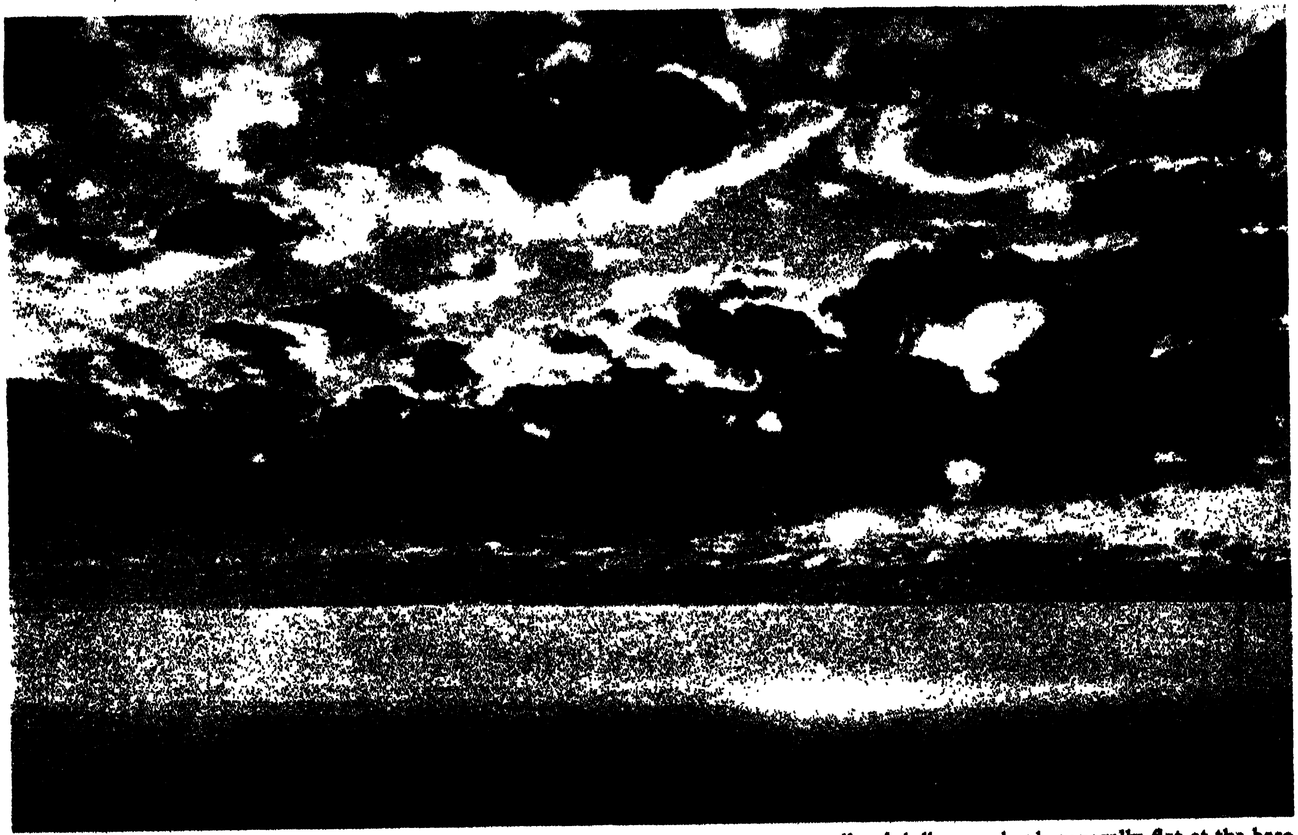


In this photograph we see Alto-stratus clouds forming above a layer of fog. This form of cloud is like a thick veil of grey getting brighter near the Sun. Sun and Moon are often faintly visible through it, but it does not produce haloes. Alto-stratus floats at between 10,000 and 25,000 feet up, the mean height being 15,000 feet. It can be distinguished from Cirro-stratus by its greyness. When Alto-stratus clouds break up they generally appear in lenticular or bean-shaped patches. They appear most often in early morning

A MOUNTAIN-LIKE MASS OF STORM CLOUD

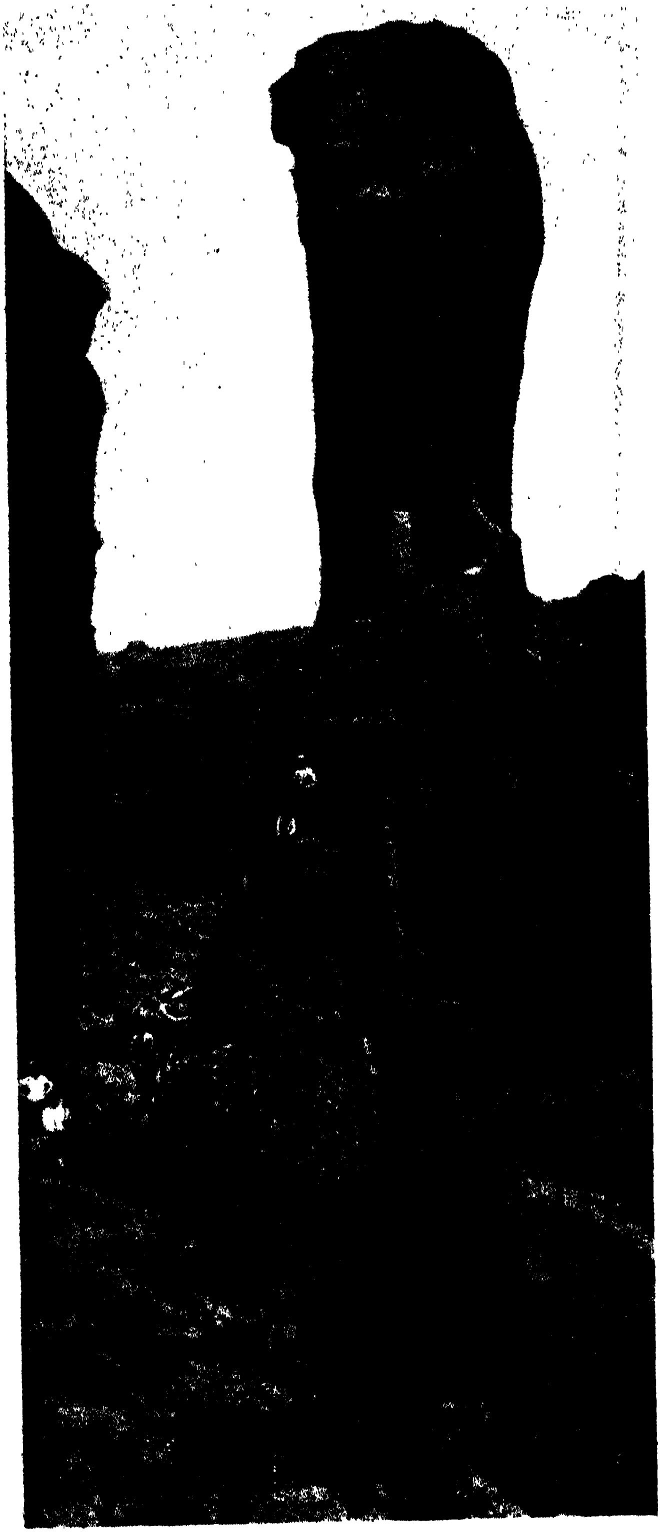


Here we see the Cumulo-nimbus cloud, which is the thunder cloud. It consists of heavy masses rising into the sky and looking like a mountain or tower. Sometimes it has the form of an anvil The Cumulo-nimbus cloud is of great depth. The bottom is sometimes no more than 600 feet above the ground, but at other times it may be 8,000 feet up. The top of the same cloud would be at its lowest 16,000 feet, and at its highest 72,000 feet up. It is generally in the form of a detached cloud covering a large area



Here we see Strato-cumulus clouds, which take the form of large lumpy masses or rolls of dull grey cloud, generally flat at the base and often covering the whole sky This form is like a great grey layer broken up into irregular masses. It can be distinguished from the Nimbus cloud by its lumpy appearance. It does not generally bring rain. The mean height is about 7,000 feet

ROCKY PILLARS SCULPTURED BY NATURE



The power of the weather in wearing away hard rock is astonishing, and is nowhere more marked than in the western regions of North America. In the left-hand photograph, for example, we see how in the Garden of the Gods, in Colorado, the soft rock has been worn away, leaving only an isolated pillar of hard basalt which has come to be known as the Totem Pole because of its fancied resemblance to the Totem Poles of the Red Indians. This rocky pillar is over a hundred feet high. But not only in America have rocky pillars been sculptured by the weather. In the right-hand photograph we see the Napes Needle, a pinnacle ninety feet high with a loose rocking top which is found on the Great Gable Mountain in Cumberland. The Needle is often climbed, and here we see some daring people who have reached its summit. In these high mountain regions the changes of temperature of the rock are very considerable, and also very sudden, and the result is that the rock is broken up. Much of it then falls, leaving these isolated pinnacles

1,600-TON SHOVEL THAT DIGS ITS OWN WEIGHT IN AN HOUR

There are two ways of digging out masses of earth or of cutting trenches in the ground. The old-fashioned and hard way is to employ gangs of men with picks and shovels who will spend many days moving only a few hundred tons of soil.

Nowadays when large quantities of earth have to be moved, contractors use various kinds of mechanical excavators to do the digging and lifting; and with one of these machines one man can lift in an hour more material than could be shifted by picks and shovels in several weeks.

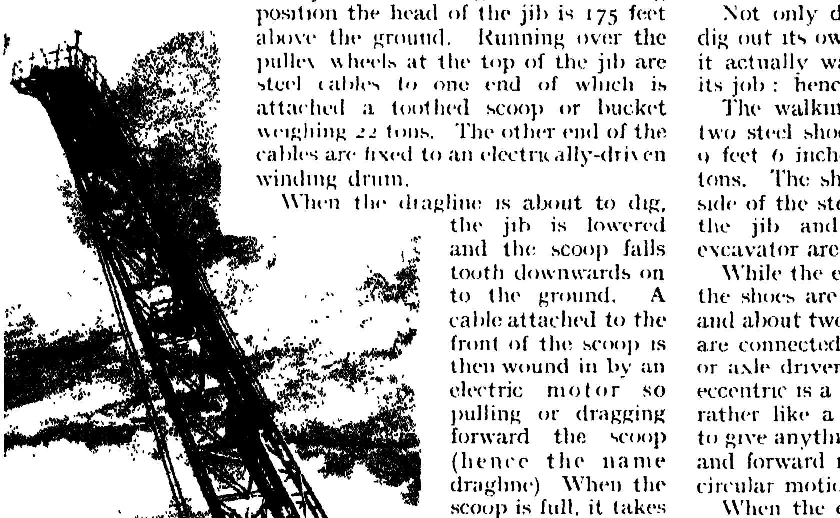
For certain digging jobs there are special kinds of excavators, such as the draglines used for removing overburden in open-cast mining. Open-cast mining is the name given to the obtaining of coal and iron-ore which does not lie very deep below the ground and therefore does not demand the sinking of shafts and the driving of galleries. The coal or ore lies under a considerable depth of earth, and this layer of soil, the overburden, must be stripped off.

In England there is a deposit of iron ore or ironstone which, beginning in Dorset, runs north-east across the country through Northamptonshire to the Yorkshire coast. It has been estimated that this great deposit contains 3,500,000,000 tons of ore, and in Northamptonshire, where it is only about 75 feet below the surface, it is obtained by open-cast mining.

Busy stripping off overburden from the iron ore at Corby in Northamptonshire is the biggest walking dragline in the world. The task of building this huge excavator began in 1947 and the stripping away of the overburden was begun in 1950.

Designed and built by the British engineering firm of Ransomes and Rapier, the Corby walking dragline weighs 1,600 tons and it has a tubular steel jib 282 feet long. In its working position the head of the jib is 175 feet above the ground. Running over the pulley wheels at the top of the jib are steel cables to one end of which is attached a toothed scoop or bucket weighing 22 tons. The other end of the cables are fixed to an electrically-driven winding drum.

When the dragline is about to dig, the jib is lowered and the scoop falls tooth downwards on to the ground. A cable attached to the front of the scoop is then wound in by an electric motor so pulling or dragging forward the scoop (hence the name dragline) When the scoop is full, it takes a bite of 27 tons of earth at one fill, the lifting cable is wound in and the load raised.



This photograph shows the 1,600-ton excavator with its jib towering 175 feet above the ground. Some idea of its great size can be obtained by comparing the figure of the man standing on the left of the scoop and the lorry on the right.

Filling the scoop, swinging it on the jib to the discharging point, emptying it, and returning the scoop to the digging position, takes one minute. The excavator is able, therefore, to dig and dump its own weight, 1,600 tons of overburden, every working hour.

The scoop can be lowered to dig out from a depth of 100 feet and empty its load 260 feet away.

Imagine how many men with picks, shovels and wheel-barrows would be needed to dig 1,600 tons of earth and stones from a hole 100 feet deep and then move the load to a distance of 260 feet; and they would have only an hour in which to do the work.

Not only does the Corby excavator dig out its own weight every hour, but it actually walks along the ground to its job: hence a walking dragline.

The walking mechanism consists of two steel shoes, each 48 feet long and 9 feet 6 inches wide and weighing 56 tons. The shoes are fixed one on each side of the steel circular base on which the jib and the machinery of the excavator are mounted.

While the excavator is standing still, the shoes are parallel with the ground and about two feet above it. The shoes are connected by eccentrics to a shaft or axle driven by electric motors. An eccentric is a mechanical device shaped rather like a pear, and its purpose is to give anything attached to it a sliding and forward movement, instead of the circular motion of a wheel.

When the eccentrics begin to move, the shoes are lowered so that their "heels" touch the ground first. This raises the base of the excavator and as the "soles" of the shoes move down to become flat on the ground the excavator is raised up and tilted forward. As the shoes move forward on to their "toes," the excavator is lowered to the ground again. Each step of the shoes moves the excavator forward for a distance of seven feet.

Here are some more facts about this huge mechanical navvy. When the excavator is digging it rests on a circular base 48 feet in diameter and four feet high. On top of the base is a ring in the form of a grooved track carrying 140 rollers, each 10 inches in diameter, on which the cabin and jib turn. The gear wheel which controls the turning is 33 feet in diameter and has 208 teeth each 19 inches deep.

The excavator is driven entirely by electric power supplied to it through two trailing cables from a power station some distance away.

One man seated in a comfortable control cabin carries out all the operations of digging, lifting, and emptying and walking the machine forward, merely by moving half a dozen levers and switches controlling the machine's 14 motors totalling 3,150 h.p.

WHAT IS CANDLE POWER?

The phrase "candle-power" is constantly used in connection with lighting, and a lamp is described as being equal to so much candle-power. What exactly does the term mean? Here is an account of this and other standards by which the intensity of light is measured

The intensity of a light, whether it be natural light such as that of the Sun, or artificial light such as that of a lighthouse or searchlight, is generally reckoned in candle-power. Now what is candle-power?

It is a unit of illumination, and consists of the light of a spermaceti candle burning at the rate of 120 grains of spermaceti an hour. Spermaceti is a fatty substance found in the head of the sperm whale, and known as "head matter."

In the old days, when all kinds of artificial lights were feeble, such a standard of measurement did very well, but to-day, when we have arc lamps and searchlights and limelight and incandescent gas mantles and gas-filled filament lamps and gas discharge lamps with powerful reflectors to concentrate the light, such a standard as the light of an old-fashioned candle to test them by seems foolish. Of course, it is all right to describe a domestic electric light as 40 or 60 or 200 candle power, but when we come to powerful searchlights we run into millions, and the figures have little meaning for us. A searchlight to guide aeroplanes at Charlottesville, in Virginia, which can be seen 250 miles away, is of 1,380,000,000 candle-power.

Such figures give us no more idea of the brightness of these powerful lights than if we said they were "x" candle-power.

When we come to the Sun's light, of course the figures get far more enormous. Professor Charles A. Young, a distinguished astronomer, tells us that the total candle-power of the Sun is 1,575 million million million million, or 1,575 followed by 24 noughts. Such figures are, of course, as incomprehensible to our minds as the distances of the remotest stars and nebulæ.

The French have adopted another standard for measuring the intensity of illuminating power. It is called the carcel, and is equal to the light of 9½ standard candles. The word is taken from the name given to a particular kind of lamp. In 1884 an International Congress of Electricians adopted still another unit. It is the light given out by a square centimetre of molten platinum at the temperature when the metal becomes solid. This unit is equal to 19·8 candles, or 2·08 carcels. It came to be known as the platinum standard, but in the following year another standard was adopted which consisted of one-twentieth of this platinum unit.

Candle-power, which is the standard generally employed for measuring the intensity of light, is the illuminating power of a spermaceti candle seven-eighths of an inch in diameter, burning 120 grains of fat in an hour.

In 1950 a new standard of candle-power was introduced based on a tube of thoria immersed in pure platinum. When the platinum is at its melting point, 1,773 degrees centigrade, the intensity of the light from the end of the tube is 58·9 international candles, or 60 "new candles" per centimetre. This new unit of candle-power is called the candella.

It must be remembered that the intensity of sunlight, that is, the intrinsic brightness of the Sun's surface, is quite a different matter from the total quantity of the Sun's light expressed in candle-power.

By the intensity of sunlight men of science mean the amount of light per square unit of luminous surface. According to careful calculations made by astronomers, the Sun's surface is about 190,000 times as bright as that of a candle flame, and about 150 times as bright as the lime of a calcium light. The artificial light which comes nearest to sunlight in intensity is the brightest part of an electric arc stuck between carbon electrodes. The light is from one-half to one-quarter as bright as the solar surface.

When we come to think of the total amount of light given out by the Sun, the figures are, of course, much more staggering. Scientists calculate that if there were an electric light of 2,000 candle-power on each square foot of the surface of the Earth, the whole quantity of light from the Earth would be less than one thousand millionth of that emitted from the Sun.

It is interesting to remember that in the case of lighthouses, the beams of which in recent years have been enormously increased in intensity, however bright the light is, there is a limit to its carrying power. There is one particular lighthouse which has a beam equal to fifty million candle-power and is seen in clear weather at a distance of 22 miles, but it cannot be distinguished at a greater distance, owing to the curvature of the Earth. The flashes of light, however, illuminating the clouds overhead may be picked up 40 or 50 miles away.

WHY WE CANNOT KEEP OUT THE COLD

In the old days, although heat came into everyday life and was used for warming and cooking, nothing was known about its true nature. Men thought that it was a kind of fluid which entered into substances and made them hot But it was not till the nineteenth century that its true nature was known. Heat is really a form of energy due to the motion of the molecules or small particles of which a substance is made up. On this page we read many interesting facts about heat

No matter how warm our clothes may be it is quite impossible for us to keep out the cold There is a very good reason for this. It is that there is no such thing as cold Heat is real enough, and we can increase the quantity of heat in our bodies or in anything else. But we can never increase the quantity of cold, because there is no cold.

Now this may seem nonsense, but it is perfectly true Cold is merely the absence of heat and the more heat we extract from a body the less heat it retains, and we say it is colder.

When we wear warm flannel garments in the winter, it is not to keep the cold out but to keep the heat in. Our bodies generate a certain amount of heat and if we wear garments made of cotton which is a good conductor of heat, the heat passes off into the air and we naturally feel cold because we have lost some of our heat.

But if we wear woollen clothes, wool, being a bad conductor of heat, does not allow the heat to pass from our body and so we retain it and feel warm. We sometimes see a vanload of ice going through the streets on a summer day, and the ice is covered with a thick woollen blanket Why is this? Well, if wool being a bad conductor of heat will not allow the heat to pass out, it will also not allow the heat to pass in.

A Blanket for the Ice

As the van of ice goes through the street and the warm rays of the Sun fall on the van, if there were no woollen cover the heat would melt the ice, but by covering the ice with a thick woollen blanket the Sun's rays cannot pass through to the ice and so it is kept in the solid state That is why it is not altogether an unwise thing to wear thin woollen garments on very hot days, for often these will keep us cooler than would thin cotton garments. The Sun's rays find it more difficult to get through the wool than through the cotton to our bodies.

Jack Frost is not a real person at all, and when we talk about wearing thicker clothes to "keep out the cold" we are only using the language of the ages of ignorance. If a thing happened to be hot men used to think it was in that condition because there was a substance known as caloric, or heat in it, and if it was cold they thought it was in that state because another substance which they called frigoric was in it

Heat is Really Energy

Of course, we now know that neither statement is true. Not only does cold not exist, but even heat is not a substance It is really a motion or activity of the particles of which a body is made up.

It is said that men catch cold more often than women, and the experiences of those who work in offices and factories and shops are suggestive that this is actually the case. The scientific explanation is that men catch cold more easily because they wear far too much clothing, and not only too much, but clothing of the wrong kind.

That we do not save ourselves from colds by piling clothes on our bodies is undoubtedly a fact. Scientific travellers tell us that the people in Tierra del Fuego rarely catch cold, although in a very inhospitable climate, with sleet and snow in winter, they go about almost naked. The chief protection of the women is their long hair, and the men's chief garment is a small piece of otter skin placed across the chest and shifted from left to right according to the direction in which the icy wind is blowing. It is a striking contrast to the clothing worn by a man in England.

Dr. Leonard Hill tells us of a curate who, even in mild winters, was always complaining how much he felt the cold. Dr Hill describes his clothing thus:

"He wore a thick llama wool vest, a thick woollen shirt, a wool-lined waistcoat, a cardigan jacket with long sleeves, a tweed suit and a wool-lined motor overcoat." This is a contrast not only to the clothing of the Tierra del Fuegians, but also to that of the average woman or girl in England to-day.

It must be remembered that our skins form an excellent heat-regulating device for our bodies, and if we cover them up too heavily with clothing, which prevents the proper ventilation of the body, the skin is unable to act properly, and our health is impaired.

Exhausting the Skin

A great deal of clothing such as that worn by the gentleman referred to above sets up excessive perspiration, and exhausts the skin by keeping it artificially too busy. Our garments should never be too closely woven for the warmth of the cloth depends less upon its thickness than upon the air in the pores of the material.

It is only when we want to protect ourselves against very strong and cold winds or against rain that we ought to put on garments that do not allow air or moisture to get through. If we constantly wear unduly heavy and badly ventilated clothing our skin may become permanently a less useful heat-regulator.

Arctic explorers, who travel into regions where the temperature is often many degrees below zero, wear fur garments, because the fur is a bad conductor of heat, and so the heat generated by their bodies is retained inside their clothes, instead of passing through the material into the air. This picture shows Sir Hubert Wilkins, the famous polar explorer, wearing clothing made of camel's hair, which is a particularly bad conductor of heat and therefore keeps the wearer very warm

HOW SUN AND THE BLANKET KEEP US WARM

The Sun is the source of heat for the Earth. Countries which get much sunshine are warm countries, and those where the Sun shines little or where his rays strike slantingly are cool or cold countries. Even the coal and oil that we burn are only giving out the heat of the Sun which has been stored up in them for millions of years. Here we see a row of children taking a sunbath. The Sun's rays pour upon their skins, bringing health and happiness to them. The Sun is hot and actually gives out a vast amount of heat

These children, like those shown in the upper photograph, are also keeping warm, and they are doing so not by sitting in the Sun, but by being wrapped up in blankets. We often speak of warm blankets, but a blanket is not warm in the same sense as the Sun or a fire or a hot-water bottle. A blanket would never make anything that was really cold warm. We put a blanket on our bed to keep us warm, but a blanket is put over a cartload of ice to keep it cold. What is the explanation ? Well, wool, of which a blanket is made, is a bad conductor of heat, that is, it will not let heat easily pass through it. When, therefore, we cover ourselves with a blanket, what the blanket does is to keep in our bodily heat and prevent it from escaping. When put over the ice it keeps out the Sun's heat

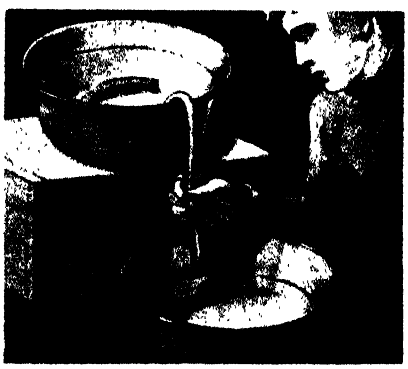
EXPERIMENTS ILLUSTRATING AIR-PRESSURE

There are many simple experiments which can be carried out to illustrate the reality of the pressure of the atmosphere. Take an ordinary funnel and over the narrow neck stretch a piece of rubber tubing with the other end over a glass tube. Now fill the funnel with water and hold up funnel and tube, as shown in the first picture. When the glass tube is higher than the funnel no water will show in it, but if it is lowered the water will appear. When lowered below the funnel, the water at once spurts out. This is due to the air pressing on the surface of the water in

Water finding its own level and (right) air supporting a tube of water

the funnel and pushing the liquid down till it reaches the same level in the narrow tube. As we read on page 185, the pressure on the water in a tube one inch in diameter is conveyed to every square inch of the water in a larger tube.

Another experiment illustrating air



A home-made siphon

pressure is shown in the second picture. We fill a glass tube with water by putting it under the water in a basin. Then, stopping up one end with our finger, we take it out and hold it as shown, with the open end of the tube below. As long as we keep our finger tightly pressed on the other end the water will not run out of the tube, for the pressure of the air underneath supports it.

The scientific principle of the siphon has been described on page 598, and we can experiment with a siphon at home by taking a length of rubber tubing and placing it in the bottom of a pan of water so that it becomes filled with liquid. Then, while letting one

The penholder supported by air-pressure

end remain under the water and pinching the other end so that no water may escape, we lift it out and hang it over the side of the pan so that the end is lower than the pan. At once the water will run out, as explained on page 598.

Here is another experiment illustrating air pressure. A tube or hollow penholder closed at one end has the air drawn out of it by the mouth, and will then remain suspended to the lip provided the flesh closes the mouth of the tube completely. It is the pressure of the air outside all round that supports the tube.

When we draw up lemonade from a glass through a straw we are really doing an experiment illustrating air pressure, for it is because we exhaust

Sucking up a liquid through a straw

the air from the straw making a vacuum inside that the pressure of the air on the lemonade in the glass drives it up into the straw.

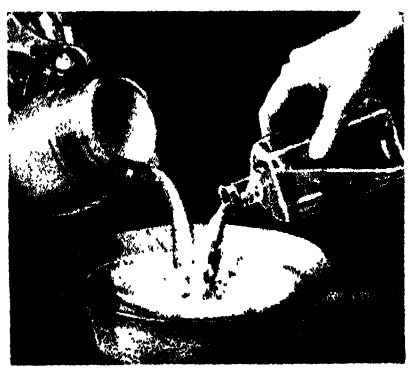
When we use an ordinary glass syringe, such as is found in most homes we are performing a similar experiment. When we put the nozzle under water and draw up the plunger a vacuum is left in the tube and the air pressure drives the water up.

Take a jug of water and a bottle of water and pour the liquid out. The water flows freely from the jug, but from the bottle it gurgles as it comes out. The jug having a wide mouth

Water driven up into the syringe by the pressure of the air

the air can get in freely, but the bottle with its narrow neck allows only a little water to get out at a time, leaving an empty space into which air pushes its way, causing the water to bubble and make the gurgling sound.

All this is a proof of how real the pressure of the atmosphere is. It is



Water poured from a jug and bottle

pressing down on everything, including our bodies, at the rate of nearly fifteen pounds on every square inch of surface, and the only reason we are not crushed by the enormous weight of air pressing on the outside of our bodies is that there is just as strong a pressure of the air inside pushing our bodies out. Of course, the higher up one goes the less is the pressure of the air, and balloons, when they rise high, expand because the outside pressure there is less than at the Earth's surface.

THE GREAT STORM IN ENGLAND

England is particularly favoured in the matter of weather It never gets those extremes which some countries experience, nor is there often a really bad storm. Once, however, a storm swept over England that did immense damage, and is known in history as the Great Storm. The amazing power of the wind was such that a stone at Shaftesbury weighing nearly four hundredweights, which had lain for some years fixed in the ground and fenced round by a bank, was lifted up by the wind and carried into a hollow seven yards from its resting place. Here is an account of this fearful tempest told from contemporary records

ENGLAND has had its Great Plague and its Great Fire, and it has also had its Great Storm, which took place on November 26th and 27th in the year 1703.

It was a real tornado, the kind of tempest that sweeps over certain areas of America, carrying away roofs, overturning vehicles, derailing trains, uprooting trees and killing people by the score. Perhaps the chief event of the storm which has kept its memory fresh is the way it treated the first Eddystone Lighthouse. The story of the rise and fall of that famous beacon is a thrilling narrative.

This Great Storm is said to have originated in the uninhabited areas of North America, and after reaching the eastern part of that continent to have swept across the Atlantic Ocean with increasing fury. It passed over Britain, crossed to France, and after sweeping across Holland, Germany, Sweden, the Baltic, Russia and Siberia, was at last lost in the Arctic Ocean.

The Storm Begins to Blow

The storm began to blow in England about eleven o'clock on the night of November 26th, and it continued in full force till about seven o'clock on the next morning. Its violence was felt chiefly in the southern part of the country, and it came as the culmination of a month of very bad and boisterous weather.

November 26th was a Friday and on the preceding Wednesday the weather had been unusually calm and fine, considering the season of the year. At four o'clock in the afternoon of that day, however, a brisk gale began to blow up, and it increased so greatly during the night that it would have been regarded as a record storm if a worse had not come a little later.

On Thursday the wind abated a little, and then on Friday it began to blow with redoubled force, till by eleven o'clock at night, as already mentioned, it blew with a force which carried everything before it.

The wind came from the south-west, and sounded like thunder of the very worst kind, continuing without a break. But actually there was no thunder or lightning, though a number of meteors were seen flashing across the sky. It was the period of new Moon, and the night was black with a darkness that could almost be felt, which added to the terror of the people.

As the storm sped along it uprooted trees, carried away roofs, and left a trail of death and destruction right across the country. At Wells in Somerset a great stack of chimneys on the bishop's palace was blown down, crashing through the roof and killing the bishop, Dr. Kidder, with his wife as they lay in bed

As the storm sped it uprooted trees, carried away houses, demolished windmills, and left a trail of death

In Sussex the sister of the Bishop of London was killed by the blowing down of her house. All over the country south of the Trent people were crushed in their beds by the collapse of their roofs, while others who had taken alarm and run into the streets or their gardens, fared no better, for they were killed by the falling bricks and tiles that were blown in all directions.

Hundreds of houses were wrecked, and 400 windmills are said to have been blown over and broken to pieces. Hundreds of thousands of cattle were swept away by the floods that resulted, and on a single level of the Severn 7,000 sheep were drowned. There were floods in many parts of the country. At Bristol the Avon rose, and the streets were flooded, so that people had to take to boats. The damage in this city alone was computed at £150,000.

"Portsmouth," says a writer of the time, "looks like a city damaged by the enemy." The spires of many churches were blown off their towers, the lead of the roofs was rolled up like parchment, and the chapel of King's College at Cambridge, one of the noblest buildings in the world, lost many of its pinnacles and had some of its priceless painted glass windows smashed by the wind. Hundreds of thousands of trees were uprooted, and parks and meadows all over the country were strewn with prostrate trunks and severed boughs.

The Terrible Toll of the Wind

Men of war and merchantmen foundered or went to pieces on sands and shoals. The *Mary*, a sixty-four gun ship, which had on board Admiral Beaumont, perished in full view of Deal, the admiral and the whole ship's company of 269 being drowned, with the exception of a single sailor.

The actual loss of life was never known, and it is believed that in compiling the death lists, or "Bills of Mortality," as they were called, an attempt was made to minimise the number of deaths so as to lessen the public consternation and fear. It has been reckoned, however, that at least 8,000 people were killed in England.

When the hurricane reached London part of the Palace of St. James's was blown down, and a woman was killed by one of the falling chimneys. Queen Anne, who had retired to rest, was greatly alarmed, and got up with her husband and all the maids of honour.

The affrighted inhabitants of the capital left their beds and took refuge in cellars and the lower apartments of their houses. Word went round that the end of the world had come. Daniel

Defoe, who went through the terrors of that dreadful night, says: "Horror and confusion seized upon all; no pen can describe it, no tongue can express it, no thought conceive it, unless some of those who were in the extremity of it."

It was not till eight o'clock on the Saturday morning, when the wind had abated slightly, that the boldest dared to venture forth from the shelter of their dwellings to see the result of the storm, or inquire after the safety of their friends and relations.

Everywhere the streets of London were thickly strewed with bricks, tiles, stones, lead, timber and all kinds of building material. Everywhere chimney stacks were blown down, and the Bills of Mortality recorded 21 deaths in London alone from falling chimneys. The records declare that after the tempest the houses of London resembled skeletons.

Defoe tells us, from personal observation, that in the county of Kent alone 1,107 dwelling houses and barns were levelled by the tremendous force of the hurricane. Five hundred of the finest trees at Penshurst, the ancient park of the Sidneys, were thrown down, and all over the county numerous orchards were totally destroyed.

Great Loss of Life

The loss sustained by the City of London was estimated at a million pounds. There was great loss of life and destruction of property on the River Thames. The tide rushed up the river with great violence and overflowed its banks, flooding Westminster Hall and all the lower parts of the city. The arches of London Bridge were almost choked by wreckage. Five hundred watermen's wherries, three hundred ship's boats, and a hundred and twenty barges were destroyed. The number of persons drowned was never known, but 22 dead bodies were washed up and buried.

Round the coast the destruction of shipping was very heavy. The English fleet, under the command of Sir Cloudesley Shovell, had just come back from the Mediterranean, and the Admiral and many of his ships were anchored near the Gunfleet sandbank, off the Essex coast, a few miles south of Harwich. These rode out the gale with little difficulty, but of the ships that were lying in the Downs few escaped. Three ships of 70 guns, one of 64, two of 56 and one of 46, with other smaller vessels, were totally destroyed, with a loss of 1,500 officers and men.

In this connection it is interesting to remember that the duty of saving the lives of shipwrecked sailors was unknown at this time. The dwellers on the coasts looked upon a shipwreck as a welcome and lawful opportunity of adding to their wealth. It never occurred to them that they should make any effort to save their fellow creatures, and indeed, there was a superstition that it was unlucky to rescue a drowning man.

At low water on the morning after the Great Storm, 200 men were seen on the Goodwin Sands crying out and waving their arms for aid. They knew that in a short time the tide must rise, and they would perish. But we are told that boatmen were too busy picking up floating property from the wrecks for their own use to worry about saving lives.

The Mayor of Deal, who seems to have been a remarkably humane man for the period, went to the Custom House and begged that the boats belonging to that establishment should be sent out to save some of the poor men on the Goodwins. It seems almost incredible that the Custom House officials refused on the ground that this was not the work for which their boats were intended.

But the Mayor was a man of strength and character. He was not to be beaten by red tape. Collecting a few of his fellow tradesmen, he harangued them and so inspired them with his own humanity and courage, that they seized the Custom House boats by force and went off to the Goodwins to rescue as many men as they could.

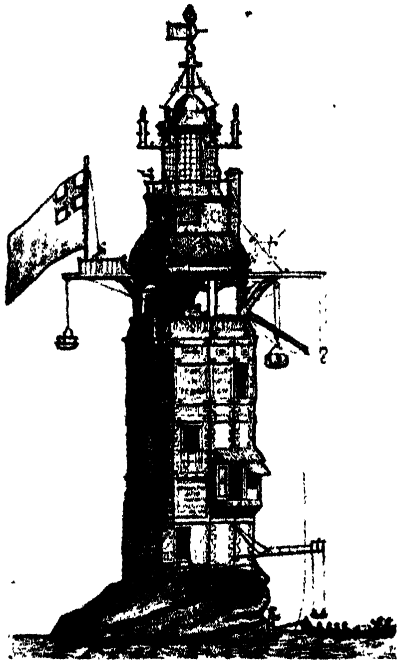
When the shipwrecked mariners were brought to land they were naked, cold and hungry, and yet the Navy agent at Deal refused to give them any assistance at all. His duties, he said, were to aid seamen wounded in battle, not shipwrecked men.

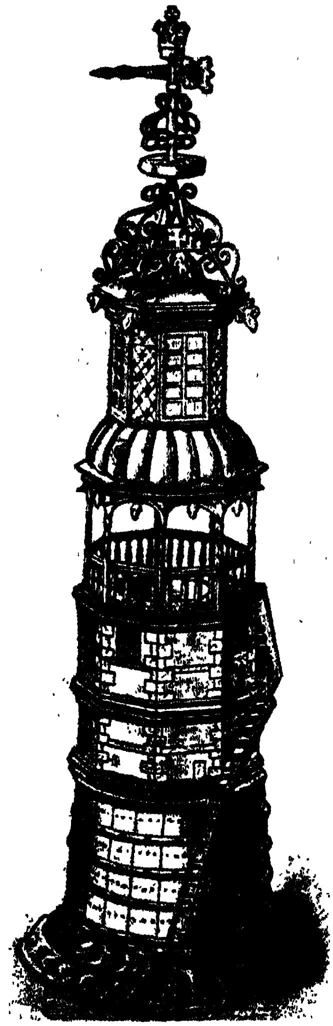
Good from the Ill Wind

This kindly Mayor therefore had to clothe and feed these poor mariners and provide them with lodgings at his own expense. He even had to pay for the burial of some that died. After many petitions to the Government he was at last repaid what he had spent, and some good came of the dreadful incident, for Parliament requested Queen Anne to place shipwrecked seamen in the same class as men wounded in action so far as succour was concerned.

There were some instances of marvellous escapes. The Registrar of Eton College, for example, Mr. Hanson, who happened to be in London, was sleeping in the upper storey of a house near Ludgate Hill. Suddenly the roof was blown away, and he himself was carried to the ground in his bed, but suffered no hurt. He afterwards declared that he knew nothing whatever of the storm till he found himself lying in his bed in the open street.

In Aldersgate Street, not far away, a man and woman were forced into a cellar by the fall of a chimney, and all hope of their being rescued alive was given up. The next morning, about eight o'clock, those digging among the ruins found the man and woman quite uninjured, and the first question the man asked was, where were his clothes that he had left in the next room, with fifty shillings in the pocket? The woman demanded to know what had become of her trunk, in which were some gold coins? The chronicle of the time mentions that "neither expressed any gratitude to either God or man."





The ill-fated first Eddystone lighthouse, before and after enlargement

The number of maimed persons throughout the country was never recorded, but it certainly ran into tens of thousands. The total material damage done in England alone amounted to about £4,000,000, an enormous sum for those days, and for long years afterwards the results of the storm could be noticed all over the country.

But the most dramatic incident of this terrible visitation, which continued with slightly lessened velocity for nearly a week, was the total destruction of the first Eddystone Lighthouse.

The Eddystone had always been a dangerous rock for shipping entering the Channel, and for centuries there had been suggestions for lighting it in some way so that mariners might be warned. One scheme was to have a coal fire burning always, but the first really practicable proposition was made by Mr. Walter Whitfield, who suggested that a lighthouse should be built.

He offered to carry out the work, provided that as a reward he should receive a share of the tolls levied on Plymouth shipping. Nothing was done, however, for some years, and then an agreement was made with Whitfield, giving him the entire proceeds of the lighthouse dues for five years, and one half for the succeeding fifty years, provided that he built the lighthouse.

He at once made experiments on the Eddystone Rock, but was not long in discovering the exceedingly dangerous and risky nature of the undertaking, and his alarm was so great that he abandoned the enterprise.

The Customs officials refused to allow the Mayor of Deal to use their boats for saving the shipwrecked mariners

Then a bolder and more venturesome man stepped into the breach, and offered to erect the lighthouse. His name was Henry Winstanley, and he was not a builder, but an artist and engraver, who among other things designed playing cards. Nor did he live near the sea, for he was born at Saffron Walden in Essex, and lived at Littlebury in the same county. He was, however, greatly interested in mechanics, and had a workshop at Littlebury, where he invented many strange devices.

He must have been something of a practical joker, too, for if you visited him, as you went into the passage of the house and trod upon a certain board of the floor, a door at the end of the passage flew open and out sprang a skeleton before you. If you went into his summer-house and sat down in front of the duckpond, the seat would suddenly swing round and you found yourself sitting over the centre of the pond.

Winstanley began building the first Eddystone Lighthouse on July 14th, 1696, when William the Third was on the throne, and the first summer was spent in making twelve holes in the rock and fastening twelve great irons to hold the work that was to be done afterwards. Winstanley hoped to be able to finish the lighthouse in the second year, and the Admiralty helped him by lending him boats and men.

Those were the days before there was any Entente Cordiale with France, so a British guardship had to stand by and watch the Rock. One foggy night in 1697, as Winstanley and his men slept on the Rock, the guardship missed her position, and anchored off Fowey, where she remained for three or four days. This proved disastrous for the lighthouse builder, for while the British guardship was away a small French privateer sent a boat with thirty armed men, who landed on the Eddystone Rock, overpowered Winstanley and his men, and forced them into the boat.

The Frenchmen stripped the men naked and turned them adrift in the boat, but Winstanley himself was taken to the warship, which sailed away.

A Guardship at the Lighthouse

When the British Admiralty heard of this outrage they were naturally very angry, but they managed to get Winstanley exchanged for a French prisoner of war, and he was soon at work again upon the Eddystone Rock.

After this experience the party of lighthouse builders was taken on board a British guardship at sunset every day, and carried back to Plymouth.

In the second year a round pillar twelve feet high and fourteen feet in diameter was erected on the Rock, and in the third year the remainder of the lighthouse, built of wood, was carried up to a height of eighty feet, and a weather vane placed on top.

At last it was finished, and on the night of November 14th, 1698, it was lighted up with tallow candles. Never was there a prouder man than Henry Winstanley. He remained on the lighthouse for some time, and then went ashore to watch the lights of the tallow candles twinkling through the darkness.

But Winstanley's beacon was very different from our idea of a lighthouse. It was indeed a wonderful structure. It had many sides, was ornamented with vanes and wooden candlesticks and decorations of all kinds. There were several projecting cranes for hauling up food and other materials, the outside was painted with strange designs.

The building was intended not merely as a lighthouse to warn mariners, but also as a fortress to resist siege, and on top was a kind of movable platform or chute which could be turned round in any direction, and from which stones could be showered upon an enemy attacking the building.

After the first winter Winstanley visited his lighthouse to see how it had borne the blasts. He found it unshaken, but as the seas had often been blown over the top of the lantern, obscuring the light, he decided to strengthen the foundations, take down the upper part of the building and rebuild it much higher. He did so, and the height was now raised to 120 feet.

One of the most amazing things recorded about this early Eddystone Lighthouse was that the keepers were constantly in danger of being carried away by press gangs.

Some people feared for the lighthouse should a really terrific storm sweep round it, but Winstanley laughed at all their fears. "I only wish," said he, "that I may be in the lighthouse in circumstances that will test its strength to the utmost." It was not long before his wish was fulfilled.

On the afternoon of November 26th, 1703, he set off in dirty weather from Plymouth for the Eddystone Rock, deciding to stay there for the night. Then came the Great Storm, with its dramatic consequences.

We know no more of what happened, except that when daylight dawned on the morning of November 27th, and men looked out towards the Eddystone Rock, there were no signs of a lighthouse. The Rock was bare as it used to be. Winstanley's structure, with its designer, had been swept away for ever by the Great Storm.

A strange thing, however, happened at Winstanley's home at Littlebury. The storm did much damage in that part of Essex, but the lighthouse designer's home was almost undamaged. During the night, however, a silver model of the reconstructed lighthouse fell to the ground.

THE SUN AS SEEN FROM MANY PLANETS

The size of the Sun as it would be seen from the different planets if we could visit them would vary very much, for while some planets are much nearer the Sun than our Earth, others are a great deal farther away. The Earth is 93 million miles from the Sun, but Mercury is only 36 million miles, while Neptune is 2,800 million miles, and Pluto, the most recently discovered planet, still farther. In this picture we see how big the Sun would look from different planets. The amount of light which the planets receive depends upon their distance from the Sun, and the quantity varies not according to the distance, but according to the square of the distance See page 778

OUR 58,000 TONS OF SUNLIGHT A YEAR

We do not think of sunlight as having weight, and to speak of an ounce of sunlight seems ridiculous. Yet men of science tell us that, as a result of their latest discoveries, they find that sunlight does actually have mass or weight, and that we can speak of so many ounces or pounds of sunlight. In these pages this curious development of science is explained

A FEW years ago it would have seemed ridiculous to talk of sunlight by weight, or to think of a ray of light as having any mass.

Of course, in Newton's time light was regarded as consisting of tiny particles of matter shot out by the source of light and passing across space to our eyes. But later the wave theory of light was devised by scientists, and during the nineteenth century this theory was supposed to be the last word on the subject.

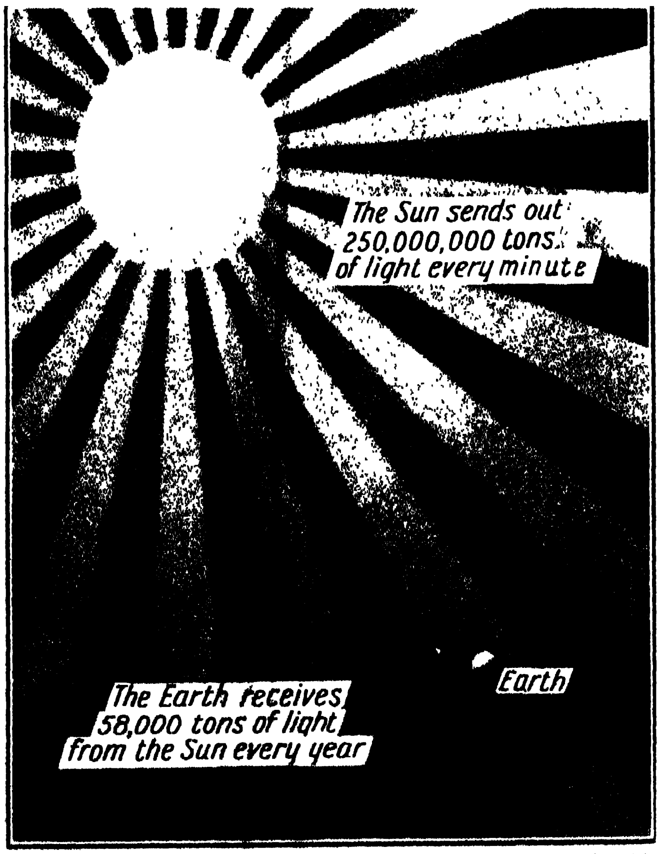
Scientists reasoned that there cannot be waves of nothing, and so they supposed that all space was filled with a material substance far lighter and more spread out than any of the elements of which the Earth is made, not excepting hydrogen gas. The waves were supposed to be waves in this very rarefied substance which was given the name of Ether.

As men of science went on with their investigations, however, this theory did not fit in with all the results that were obtained by experiments. Professor Einstein, the great German physicist, who elaborated the theory known as Relativity (about which we read on pages 487 to 491) declared that light was affected by gravitation. He maintained that a beam of light coming to the Earth from a distant star, if it passed near the Sun, would be drawn aside as though by the Sun's pull.

It was therefore decided during a total eclipse of the Sun, to test this theory, and on May 29th, 1919, two British expeditions, which had gone to different parts of the world to study a total eclipse of the Sun on that day, found that Einstein was right.

It was noted that a beam of light coming from a star was definitely bent as it passed the Sun. Photographs were taken of two stars in a group known as the Hyades in the constellation of Taurus, or the Bull, and the photographs definitely showed a displacement of the stars, which meant the bending of the ray of light coming from them.

Since then other experiments have shown that the wave theory of light does not account for all the facts in connection with light. Light behaves at times as though it had mass, or substance, and it is curious that though we have not gone back to Newton's theory of light, namely, that it consists of small particles or corpuscles of solid matter, yet some of the results we get are such as Newton expected.



The light of the Sun is now known to have weight, and in this picture-diagram we see the mass or weight of sunshine which the Earth receives from the Sun every year

In his work "Opticks," he says: "Do not bodies act upon light at a distance, and by their action bend its rays." That is just what does happen.

Einstein's theory distinctly shows that light has mass, and men of science are able to calculate that the light received from the Sun by the Earth in the course of a year is rather more than 58,000 tons, yet this is only a fragment of the radiation sent out altogether by the Sun, which is equal to 250 million tons a minute.

It is calculated that about a ten-thousandth of an ounce of sunlight falls every minute on every square mile of land. This, according to Sir James Jeans, means that the total weight of sunshine that falls on a given space in a century is less than the weight of rain falling on that space during a heavy shower in the fiftieth of a second.

The present belief of science, owing to the coming of Relativity, is that light consists of neither waves nor particles, but that it partakes of the nature of both waves and particles or, in other words, that it behaves like both.

The Einstein theory of Relativity is a very complicated business that only those with an exhaustive knowledge of higher mathematics can possibly hope to grasp in detail. It concerns not only light, but everything in the Universe, including matter, space and time.

We think of these things as quite separate. We think, for instance, of a planet or a sun weighing so many tons and moving at such and such a rate through so many miles. But according to the Theory of Relativity things should not be thought of as though they were in separate compartments. There is no such thing as time or place or size apart from the relation of such things to other things. The place or time of an event, says the scientist, depends on its relations to other events, and these relations are different for different observers.

The universe, with everything in it, instead of consisting of only three dimensions, length, breadth and depth, has really four dimensions, length, breadth, depth and time, and these, says the Theory of Relativity, may vary for every observer.

The scientist thinks of the universe now, not as masses in space changing their relative positions in time, but almost as a number of events. Two events which for any particular observer occur at one instant may for other observers be separated by an interval,

and there is no absolute place for anything, because any two events which for one observer happen in one place, may be in different places for other observers.

To the modern scientist who thus thinks in mathematics, the ether filling all space, which was formerly needed for the wave theory of light, does not exist in any real material sense. He no longer thinks of infinite space consisting of length, breadth and depth, filled with ether, but talks of a " space-time continuum." Just as we think of a sheet of paper which has length and breadth as being a space of two dimensions; or of a cube with length, breadth and depth as being a space with three dimensions, so a scientist thinks of the Universe as a space with four dimensions, length, breadth, depth and time.

Of course, ordinary people like ourselves cannot picture these four dimensions as one thing. We can, however, get some idea or hint of what the scientist is driving at from simple illustrations. One illustration is that of what we know as a light-year. This is a combination of space and time. In one sense it is the space or distance which a ray of light travels in a year. In another sense it is the time in which a ray of light takes to travel 5,876,068,880,000 miles. The term light-year combines the two ideas, time and space.

Another illustration is that of the train which is given on page 488

It is all very difficult to those of us who can think of things only in three dimensions with time as a separate affair altogether The illustrations, however, given on pages 486 to 491 will help us to get some idea of how one thing and one event are related to others and how time as well as length and breadth and depth enter into things

When Einstein propounded his Theory of Relativity, it was not known that a ray of light passing through space could be bent as by gravitation, but this proved to be the case. Other proofs of the Theory of Relativity have also been obtained.

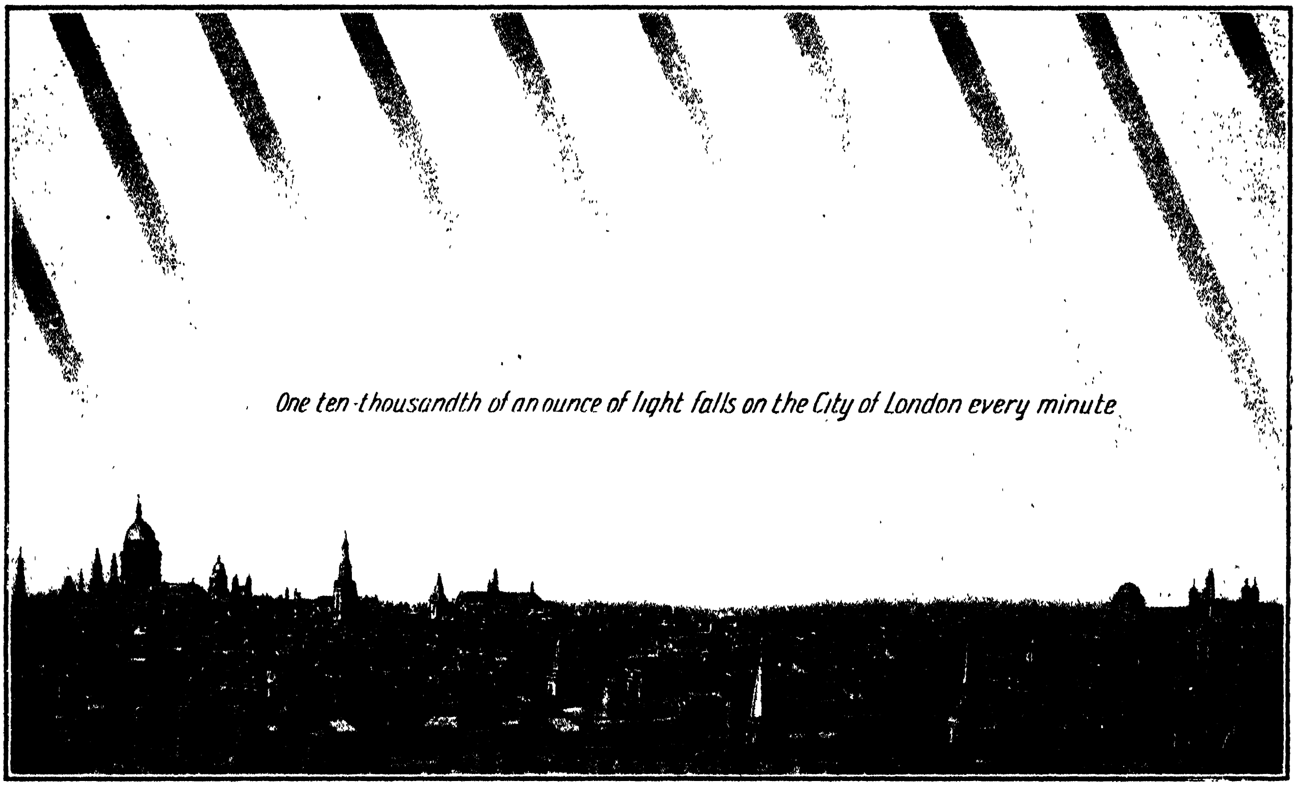
For instance, the movement of the planet Mercury in its journey round the Sun did not fall in exactly with Newton's Law of Gravitation, but Einstein's new principle for calculating gravitation was found to fall in with and explain the apparent irregularity of Mercury's orbit.

Einstein teaches that size and mass depend on speed of movement, and that mass increases at high speeds. He points out that space and time have no real distinction. We separate them only for convenience in thinking.

His Theory upsets much of Euclid's geometry, for according to the German scientist parallel lines do eventually meet, straight lines are not straight, space is not infinite but curves round, a circle is not really circular, and the three angles of a triangle do not necessarily together equal two right-angles.

Gravitation is not now thought of as a force acting across space and pulling things—the Sun, for example, pulling the Earth and the Earth in turn pulling the Sun. The law of gravitation is now regarded by men of science as a mathematical formula giving the rate at which a moving body changes its speed of motion.

Newton regarded a mass of matter as exerting a force, but Einstein regards the matter as distorting the four-dimensional continuum in its neighbourhood. In other words, the apple falls from the tree not by the pull of a force but by a curvature of the continuum As Sir James Jeans says, " Gravitational forces now disappear, leaving nothing but a crumpled continuum "



Although men of science have discovered that sunlight has mass or weight, and that the Sun gives out 250 million tons of radiation every minute the amount that falls upon any square mile, such as the City of London, is very small when reckoned in terms of weight

This is about the simplest way in which the ideas of relativity can be explained, but we must remember that for ordinary people dealing with the ordinary facts of life we may still follow Euclid in geometry and Newton in gravitation.

It would not do in the ordinary everyday affairs of life, as for example in the laying of railway lines, to act as though parallel lines were not always the same distance apart, or in the unloading of a ship to think that Newton's idea of gravitation was no longer true. All these new ideas affect only the higher branches of science, which do not concern ordinary people as they go about their daily life.

A GREAT ORCHESTRA PLAYED BY ONE MAN

A big organ is a very wonderful instrument. It is really a complete orchestra played by one man. There seems to be no limit to the size of an organ, and one of the largest of these instruments, built and played in America, is described in these pages. The keyboard of a modern organ need not be near the pipes, for organs can now be played electrically and the keyboard can be hundreds of feet from the organ itself. In modern cinema organs, in addition to the pipes, various instruments of percussion are also played from the keyboard, as shown in the drawings on pages 654 and 655.

THE organ has been described as the most perfect musical instrument that the ingenuity of man has hitherto devised, and the description is a true one. It is as much a triumph of the mind of man as is a great electric power station, a vast cathedral, or a giant liner. Starting from the smallest beginnings, the organ has now reached dimensions that almost bewilder the imagination.

Away back in the distant past some man heard strange sounds as the passing breezes struck against the open ends of the broken reeds that grew by the river side. The reeds were of different lengths, and the murmurs varied as the wind played first over the long pipes and then over the short ones.

We know not who the man was, but some inventive genius of those distant days saw in this playing of Nature's music a great idea. He gathered the dry stems of reeds, and breaking or cutting them to different lengths fastened them together to make the instrument which we call Pan's pipes. Holding this to his lips he blew across the reeds and produced the first real instrumental music made by man.

But he did more than that. He began the invention of the organ, the most glorious of all musical instruments, and one of the marvels of the modern world.

It is no exaggeration to say that the organ, forming as it does a combination of many wind instruments, is really a great orchestra, with one player instead of many. Even the huge organ which is pictured in these pages, and is the biggest musical instrument in the world, can be played quite easily by one man, who can open and shut at his pleasure the thousands of valves which regulate the pitch of the sound.

The invention of the organ did not come suddenly. It was developed over the course of centuries, and although in ancient times there were organs in which the wind was blown through the pipes by means of water-power, so that they were called water-organs, the organ as we know it to-day is a product of the Middle Ages.

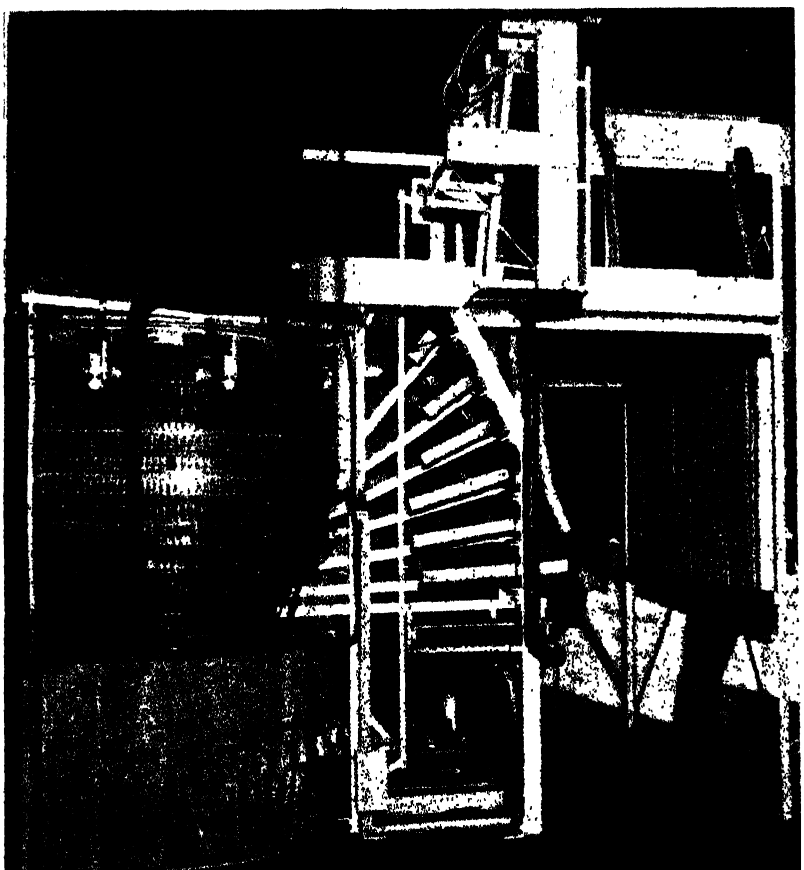
The old organs were very small and had as a rule only from eight to fifteen pipes. They were used chiefly in teaching singing, and their compass was only one octave. No pipe was longer than four feet. The keyboard consisted of upright wooden plates, and the performer pressed these down to admit the wind to the pipes. The sound lasted till they were restored to their upright position.

Gradually the organ was developed by the division of the pipe work into registers or "stops," which are simply sets of organ pipes. The old small organs had been easy to play, but as the instrument became more complicated the organist had to be something of an athlete, for the keys could only be moved by being struck hard with the fists or pressed down with all the force of the elbows.

Ingenious men, however, set to work, and the mechanism was simplified so that the pressing of a key with the finger would produce a note of any volume.

Nowadays a large organ is divided up into departments which may almost be regarded as separate instruments. There is the great-organ or grand-organ, whose large pipes appear in the front of the instrument, and give the most majestic notes. Behind it is the choir-organ, with less powerful notes. It is often used to accompany the human voice. Then above this is the swell-organ, with its pipes enclosed in a wooden box, that has a front of upright boards that can be opened and closed like Venetian blinds, by pressing on a pedal. In this way the sounds can be increased or decreased in power.

The pipes of the organ are of two

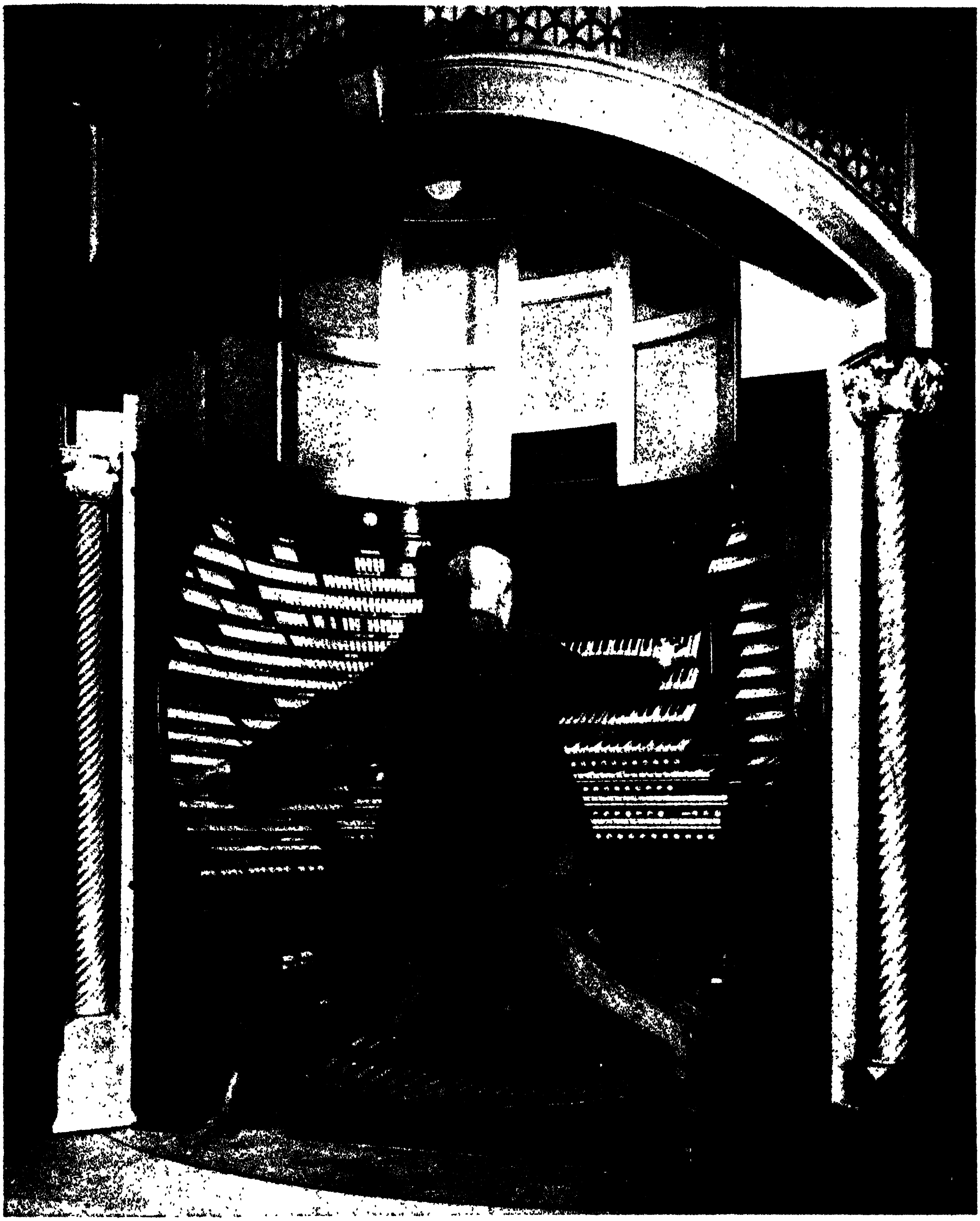


The machinery at the back of the keyboard of the giant organ at Atlantic City, and the electric cables that connect the keys with the pipe valves and stops

AN ORGAN WITH MORE THAN 1,000 STOPS

One of the biggest organs in the world is at Atlantic City, New Jersey, and has 1,233 stops. Here we see the left stop-jamb, that is, one of the places where the organist operates the various stops. There is a similar tier on the right-hand side of the keyboards. Each stop of an organ consists of a series of pipes similar in tone and quality, running through a great part of the compass of the instrument. By means of the apparatus shown here the organist can change the quality and tone, the power of sound, and also the compass or range of sound while he is playing. The bellows of this great organ are blown by means of electrically driven blowers

PLAYING AN ORGAN WITH 487 KEYS



The organ at Altantic City has seven manuals or keyboards and there are 487 keys. In addition there are 32 pedal keys to be worked with the feet. In order that the organist may be able to reach all the keys easily the upper three keyboards are inclined towards him, and are not horizontal like the lower ones. This organ, which has been built by the firm of Midmer-Losh, has 32,882 pipes. The back of the keyboards is shown in the photograph on page 901. This and the other excellent photographs of the organ are given by courtesy of the American Organist, and were taken by Fred Hess & Son, of Atlantic City

main classes, known as flue-pipes and reed-pipes, and some are made of wood and others of metal. The larger pipes are flue-pipes, and these are often of deal, pine or cedar, and sometimes of oak, mahogany or maple

The tone of a flue-pipe is produced by the vibration of a current of compressed air, which is forced through a slit over a sharp edge. The pitch of the note depends on the length of the pipe, and in some cases the pipe is open at the top and in other cases stopped by a plug, so that the air has to travel along the pipe twice before making its exit, and in this way the length of the pipe is doubled, which means that the pitch of the note is halved.

Flue-pipes are sometimes made of metal, the most suitable metal being tin, and the least suitable lead. Zinc is sometimes used in large pipes for cheapness. When the pipes are of metal they are made cylindrical, but when of wood they have a square or oblong section.

The reed-pipe is a tube of metal with the front part cut away and a metal tongue or spring inserted. The lower end of this tongue is free, while the upper end is fastened to the top of the reed. When air enters the pipe the tongue vibrates and moves the reed, producing a musical note. The pitch depends on the length of the tongue.

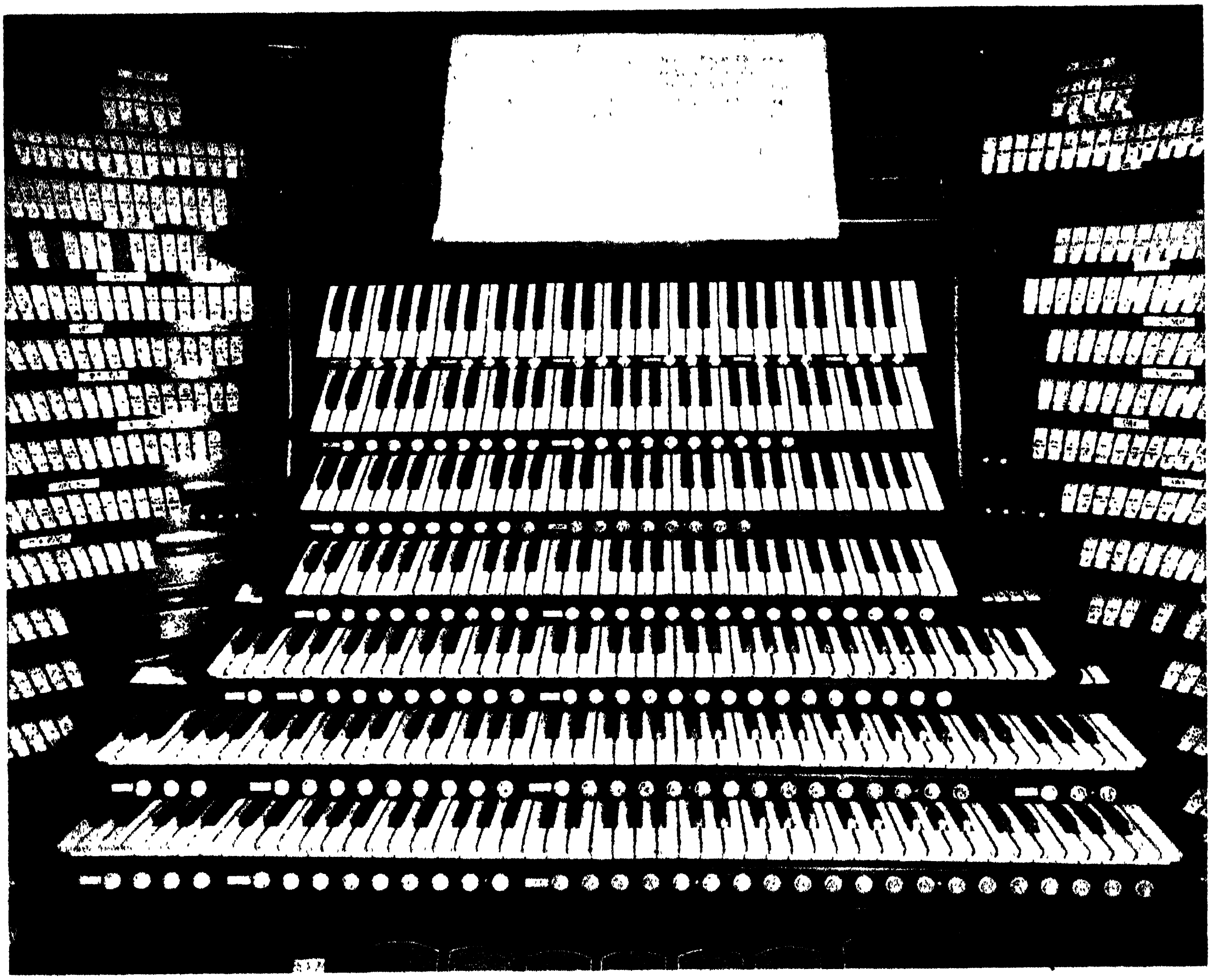
The stops of an organ, which are collections of pipes of similar tone and quality, are played by operating stop-tongues on the left and right of the keyboard. These when pulled out or pushed in move perforated boards which act as valves, letting in the wind or shutting it off from each series of pipes. The organ is played from a set of keyboards which vary in number. There are never less than two keyboards and generally four.

In modern organs the bellows are usually worked by electric or hydraulic power, instead of by hand, and the pressing down of the keys admits the wind to the pipes. The wind does not pass direct from the bellows, but goes first into a wind chest so that the flow shall be continuous and not jerky.

There are now some very large organs in different parts of the world. One of the biggest church organs in England is at Liverpool Cathedral. The biggest organ in America is a magnificent instrument which stands in the Convention Hall at Atlantic City, New Jersey. It has no fewer than seven keyboards, with 487 keys to be operated by the fingers, 32 pedal keys for the feet, 1,233 stop-tongues in the left and right jambs operating the stops, and 32,882 pipes. The bellows are worked by seven electric blowers totalling 404 horse-power. Yet although it is so huge it can be worked quite conveniently by one player.

The hall in which it stands is so big that a thirteen-storey building could be erected in its centre. It seats an audience of 41,000 people.

In many large cinemas electric organs have taken the place of orchestras and are provided with tone controls which make it possible for the organist to play orchestral pieces with the sounds of the appropriate instruments.

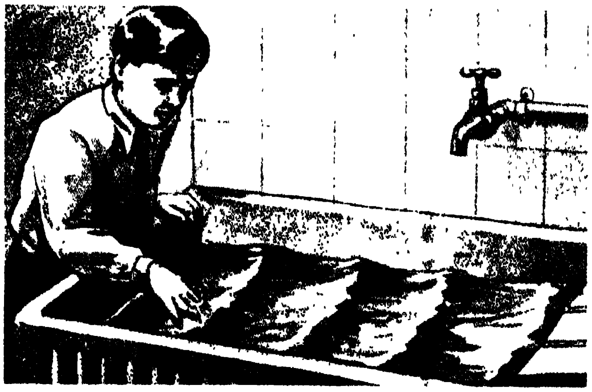


The seven manuals of the great organ keyboard as the player sees them in front of him, with their 487 keys to be played by hand

EXPERIMENTS IN THE SCIENCE OF SOUND

There are many experiments which we can perform in the home illustrating the science of sound, and some are given on this page.

Sound as we know consists of waves or vibrations in the air. If we half fill the kitchen sink with water and start a wave at one end we shall see the wave travel across the water, and when it reaches the other end of the sink it will be reflected back. Sound waves travel in the same way. They go on till they strike something, and are then reflected back. That is why a pulpit has a sounding-board. When the preacher's voice rises to the sounding-board the sound waves are reflected downwards so that they may reach the ears of those sitting below in the pews.

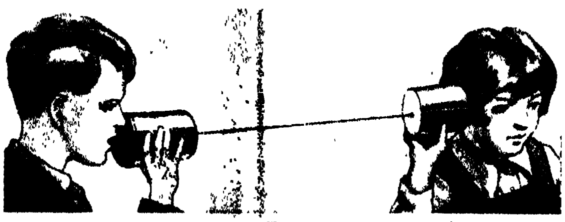


Waves of water to illustrate waves of sound and, on the right, sound waves transmitted through string from a tablespoon swung against a table

That sound waves travel not only through the air but through solid substances can be proved by an experiment with a tablespoon and a piece of twine. We tie the twine round the handle of the spoon as shown in the second picture, and hold the ends of the string in our ears. Now we swing the string and allow the spoon to strike the edge of a table or some other solid body.

The sound which we hear will be very loud indeed, much louder than if the waves travelled through the air, for then they would spread out and their force be reduced. The waves travelling through the twine reach the ears with undiminished force.

A simple telephone which will illustrate how sound waves travel through solid substance can be constructed as shown in the third picture. We take two cylinders of tin with both ends open. Ordinary domestic tins with the bottoms cut off will do. Then we tie some parchment or grease-proof paper round one end, and taking a length of thread or cotton pass it through the middle of the parchments, tying knots to keep it from slipping out again. If we speak into one tin a person listening at the other end will hear what we say, though the thread may be thirty feet long. The cotton must be kept taut.



A home-made telephone. The cotton can, of course, be 30 or 40 feet long, but must be kept taut

Still another experiment with thread or string is shown in one of the bottom pictures. We put our hands over our ears and get someone to put a string or cord round our head and hands and pull it taut holding the end in one hand. Now if he draws his finger and thumb lightly along the cord we shall hear a loud rolling sound like thunder. The sounds made by rubbing the string, which are scarcely perceptible when listened to in the ordinary way, are loud when heard through the medium of the string and hands, because considerable vibrations are set up by the fingering.

If we take a tuning fork and tap it and then place the end to our lips we shall feel vibrations almost like an electric shock. These vibrations are, of course, many to the second, and their rapid succession gives the effect of a shock.

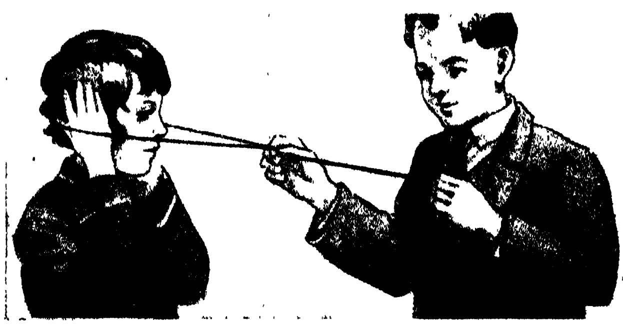
In Victorian days, when most homes had large shells standing as ornaments on the mantelpiece, it was a common practice to ask a child to hold a shell to his ear with the remark that he would hear the roaring of the waves. Certainly the sound that one hears when holding a shell close to the ear is very much like the waves breaking on the shore, but, of course, the sounds are not caused by the sea.

The shell picks up all sorts of slight sounds that are going on round about us, but which are too feeble to be heard in ordinary way. In other words, the shell collects the sound waves and concentrates them into a small space, so that instead of being dissipated in the air they can be heard by us. If there were no sounds in the room when we put the shell to our ear it would be quite silent.

Such collection of feeble sounds does not require a sea shell, but other objects of a somewhat similar shape will enable us to "hear the sea" just as well. It is possible to screw up the hand into somewhat of a shell shape and hear sounds that it collects.

The experiments with the cord or string will suggest various other ways in which we can prove that sound vibrations travel through solid bodies.

Listening to the sounds caught in a seashell



Sending sound waves along a cord placed round the head and hands and drawn tight

Feeling the vibrations of tuning fork on the lips

BEACHY HEAD FALLING INTO THE SEA

The sea is busily engaged in eating away the coast of England, and how effectively it is doing its work can be seen by this photograph taken at Beachy Head. The power of the waves has undermined the great cliff, pounding at it till huge blocks have been broken away, and sooner or later the overhanging crag will become weathered and fall by its own weight. Then the sea, continuing its work, will hurl the great blocks of stone to and fro till at last it smashes them up, and they will eventually become pebbles and then sand. The action of the atmosphere splits even the hardest rock, and then the mere weight of thousands of tons of water being suddenly hurled against the cliff soon loosens and detaches big fragments of rock. These fragments are then used as battering-rams by the sea

THE SEA AS A BITTER ENEMY OF MAN

The sea is never tamed. Man, with all the marvellous power that he has developed through using his brain, has done much to make the sea his servant, but when it gets angry it breaks out into hostilities and man is helpless. Whether it be in the smashing of his sea walls, the invasion of his coast lines, or the wrecking of his ships, the sea is an untamed enemy, and here we read something about this characteristic of the sea and its work

In many ways the sea is our friend. It forms a far easier means of communication between distant countries than great stretches of land, with their mountains and deserts and wide rivers to cross, and for a country like Great Britain it equalises the temperature, saving us from those extremes of heat and cold which countries in a similar latitude far removed from the sea experience.

At the same time the sea is in many ways our enemy It is making a constant warfare upon our coasts, eating away our little island home, and rendering necessary the expenditure of a vast deal of labour and money to resist its encroachments. On the east coast of Britain at various points from north to south the sea has been for centuries battering away at the land, making a breach here and a breach there, and at last invading the haunts of man and capturing for ever large areas which now lie at the bottom of the sea.

This encroachment is not carried out at such a slow rate that we cannot see it going on. The smashing of the cliffs at Beachy Head, the breaking up of the sea front near Lowestoft, and the eating away of the cliffs at places like Cromer and Dunwich and the Reculvers are evidence before our eyes of the relentless will to war of the waves.

On the continent of Europe nations talk of maintaining their frontiers inviolate; but people like the Britons, whose frontiers are the sea, can never keep these frontiers unaltered. The sea coast is ever changing. Waves and currents are working vigorously to wear away the land, moving great fragments of rock and breaking them up and then carrying the smaller fragments farther along the coast and dropping them sometimes where they are least wanted.

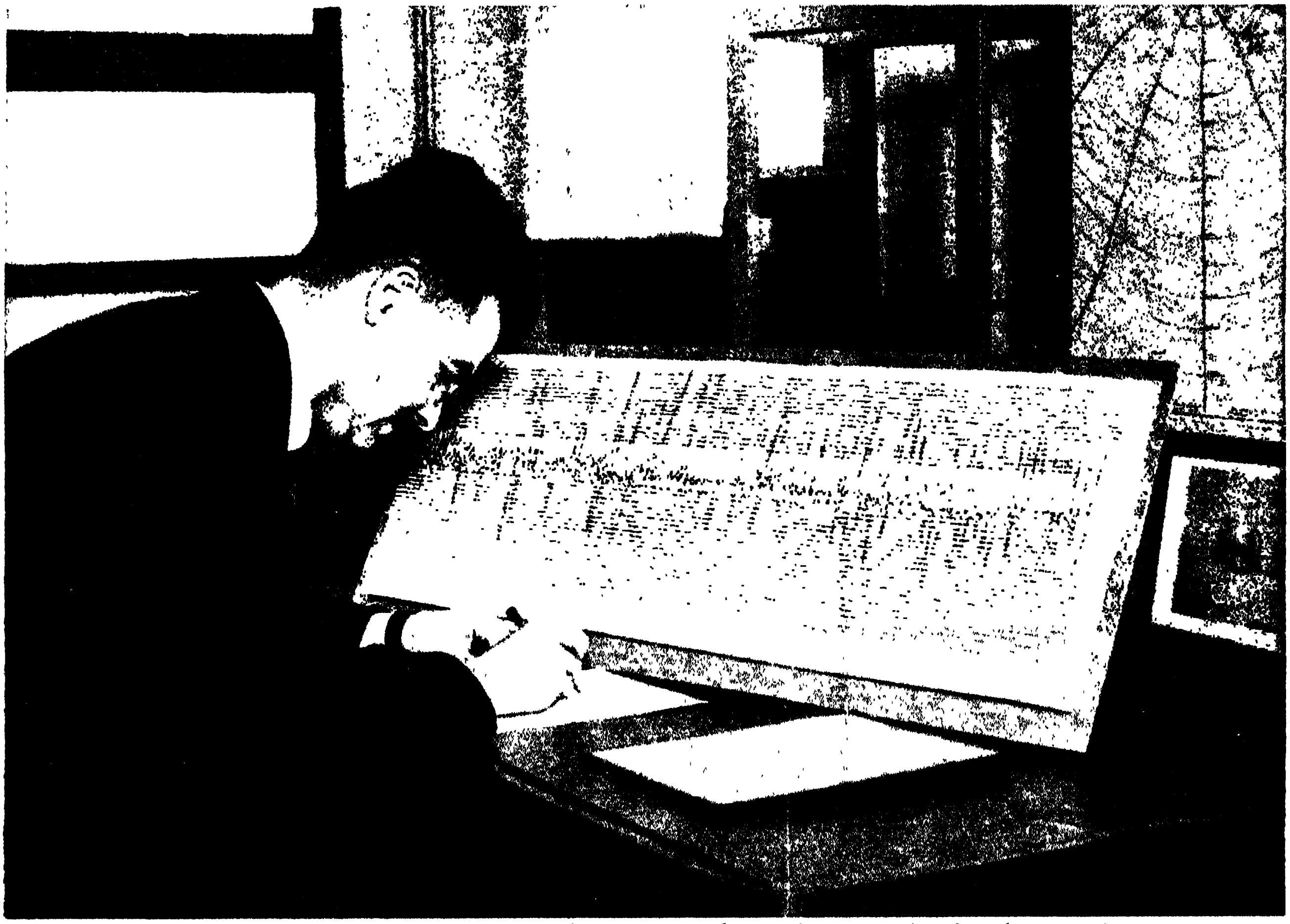
At one place, such as the coast of Yorkshire or the coast of Sussex, the shore is smashed up and a town gradually captured till it is submerged; while in another place, as at Rye, the sea gives up its captures and leaves what was once a flourishing seaport two miles inland.

Of course, this kind of thing goes on not only in England but all over the world. Some coasts, like that of Cape Cod in Massachusetts, are being cut away by the sea at the rate of a foot or two a year. In other places, as on the west coast of Italy, the sea is depositing matter and building up the coast, so that a city like Pisa, which in the Middle Ages was a prosperous seaport, is now several miles inland.

There are other ways in which the sea is the enemy of mankind. It resents its attempted conquest by man and wrecks his ships, throwing them angrily upon the rocky coasts

A striking example of the merciless fury of the waves. The photograph shows all that is left of a ship that was hurled upon the rocky coast at Stonehaven in Scotland by the cruel waves and smashed to fragments, the whole of its crew being lost

THE RECORD OF AN EARTHQUAKE 6,000 MILES AWAY



By means of that remarkable instrument, the seismograph, we can now know when an earthquake takes place in any part of the world. Even if it occurs under the sea the instrument records it, and the record made indicates whether the earthquake was a small or great one. We can see on page 674 how the seismograph works, and here is the actual record which such an instrument made in London of an earthquake that took place in a Pacific island, 6,000 miles away. The intensity of the shocks is indicated by the way in which the line travels up and down. Nearly all countries now have their seismographs stationed in different areas, and when an earthquake occurs its position can be more or less worked out from the records that are made by the different seismographs. Even the lightest earth tremors are recorded on these delicate instruments.

WHY WE CAN SEE THE SUN AFTER IT HAS SUNK

The atmosphere which surrounds our Earth is responsible for some strange phenomena. We have already seen (pages 385 and 620) how the atmosphere causes haloes and rings to appear round the Sun and Moon, and there are many other strange freaks that result from atmospheric conditions. The mirage of the desert and the looming of the northern seas are examples of these. Another example is the twinkling of the stars.

It is to the atmosphere that we owe the twilight which in the latitude of Great Britain makes the day merge into night very gradually. After the Sun has gone below the horizon and is no longer directly visible, his light is reflected and diffracted, or broken up, by the many particles in the upper atmosphere, so that we see the light for a considerable time after the source of light has disappeared. It has been found by scientists that there are enough particles above the height of a hundred miles to send a perceptible amount of light to an observer.

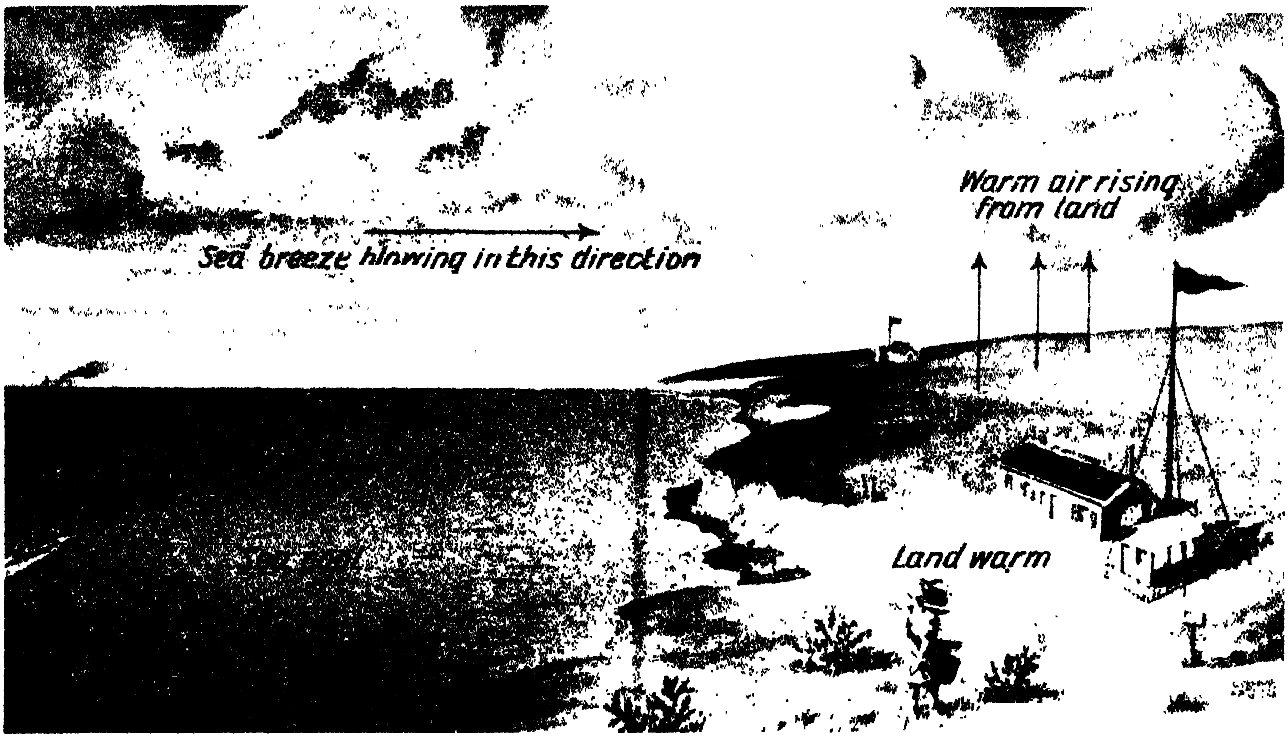
Of course, the duration of the twilight varies a great deal at different times of the year, and at different places. In the Polar regions it lasts for months.

When a ray of light passes from a medium of one density into that of another it is bent. This has been already explained on pages 221 and 222. The atmosphere is in layers of different density, and a ray of light entering the Earth's atmosphere from Space passes through these layers which get steadily denser as they reach the Earth's surface. The ray of light is consequently bent again and again and as a result both the Sun and the Moon come into our view before they have actually risen above the horizon in the morning, and are still visible to us after they have really set in the evening. In other words, the rays of light from them are bent as they pass through the layers of varying density in the atmosphere and they appear higher up in the sky than they really are. The result is that in a latitude like that of England the period of day in which the Sun is seen above the horizon is lengthened from four to eight minutes.

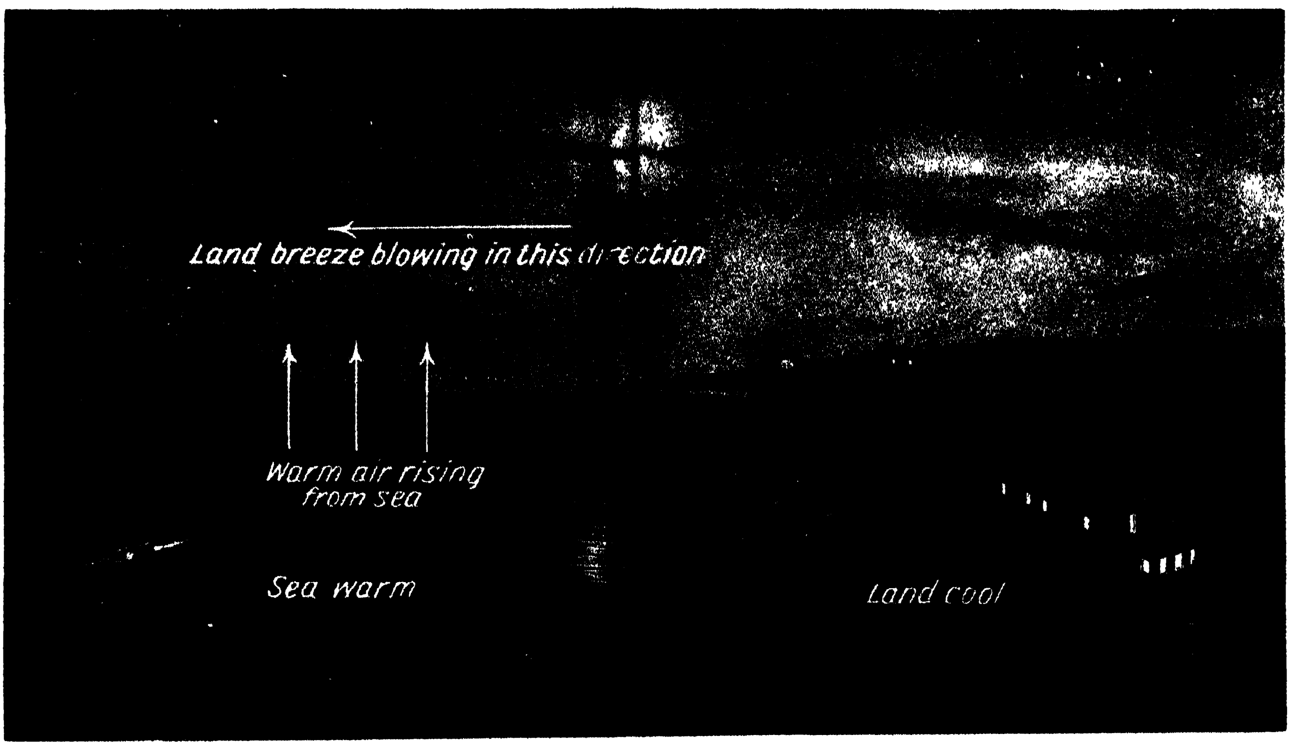
The flattened sun as it sinks below the horizon

The effect of refraction in the atmosphere is to raise all distant objects, to lengthen the day and to flatten the disc of the Sun and Moon when rising and setting. The lower edge of the Sun or Moon is raised more than the upper edge, and so the body has a flattened appearance, as shown in the picture here. This curious distortion of the Sun's disc is sometimes to be seen in England just before sunset.

LAND AND SEA BREEZES AND THEIR CAUSE

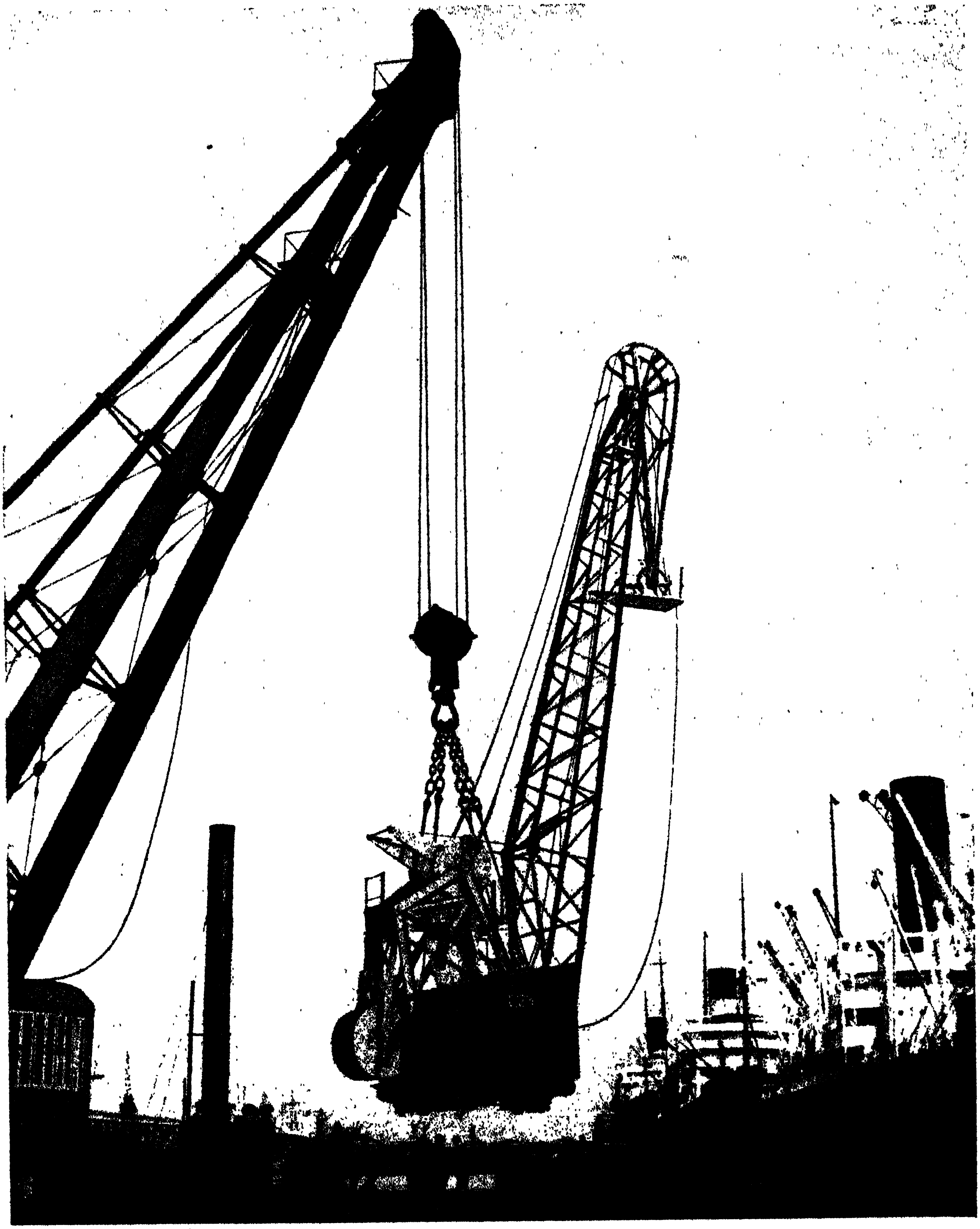


Even under the calmest conditions there is always a breeze blowing at the seaside. In the daytime it blows from the sea upon the land, and at night from the land towards the sea. The pictures on this page show why the land and sea breezes blow in this way Here in this top picture we have the conditions that make a sea breeze. During the day the land, being a solid, takes up heat from the Sun more quickly than the adjacent water, and warms the air above it, so that this rises, and the cooler air that is over the sea flows in to take its place Thus a constant stream of cool air is passing over the land from the sea



Here we see the conditions that produce a land breeze, that is, a wind blowing from the land towards the sea. At night the land that has become heated during the day gives up its heat rapidly, and becomes cool. But the sea, which was slow in taking in the Sun's heat, is also slow in giving it up. The result is that the land is cooler than the sea. Warm air over the sea therefore rises, and cool air from the land flows in to take its place. The arrows in these pictures show the direction of the air currents, not the winds themselves

THE GIANT CRANE LIFTS ITS SMALLER BROTHER



Modern docks are equipped with a variety of cranes ranging from small types for light work to giants that are capable of raising a locomotive as easily as a boy lifts a toy engine. The larger types of crane are worked by hydraulic power, and here we see a giant crane at the George V Dock, in London, which has been christened Hercules, lifting another crane into position for the unloading of ships. The crane that is being lifted looks like the big crane's little brother, but is really a giant in itself and can lift several tons.

THE USEFUL WORK OF THE GIANT CRANE

Without powerful cranes the work of loading and unloading ships at the docks could never be carried out with sufficient speed. In the old days when the volume of business was small gangs of men with very little mechanical aid could empty the much smaller vessels that then entered the docks. Now, however, with giant ships, giant cranes are needed as time-savers, and here we read about them

When we look at a great crane lifting a heavy body like a locomotive and swinging it on to a ship for transport abroad, we may wonder how the Ancients were ever able to lift and place in position such huge stones as rested on the upright pillars at Stonehenge. To move such stones in these days would require quite a large crane, and yet the Ancients had practically no machinery.

We must remember, however, that while they performed such tasks they were only able to do it by using a vast amount of human labour and spreading the work over a great period of time. It is something like the case of the pulley or the lever. In the lever, by exerting a small force through a great distance at the end of a long arm, we can move a heavy weight through a short distance.

Well, nowadays, by means of a modern crane, we can lift a very great weight in a short time because we have found how to exert a great force in a small space—that is, we use steam, or hydraulic or electric power to work the crane.

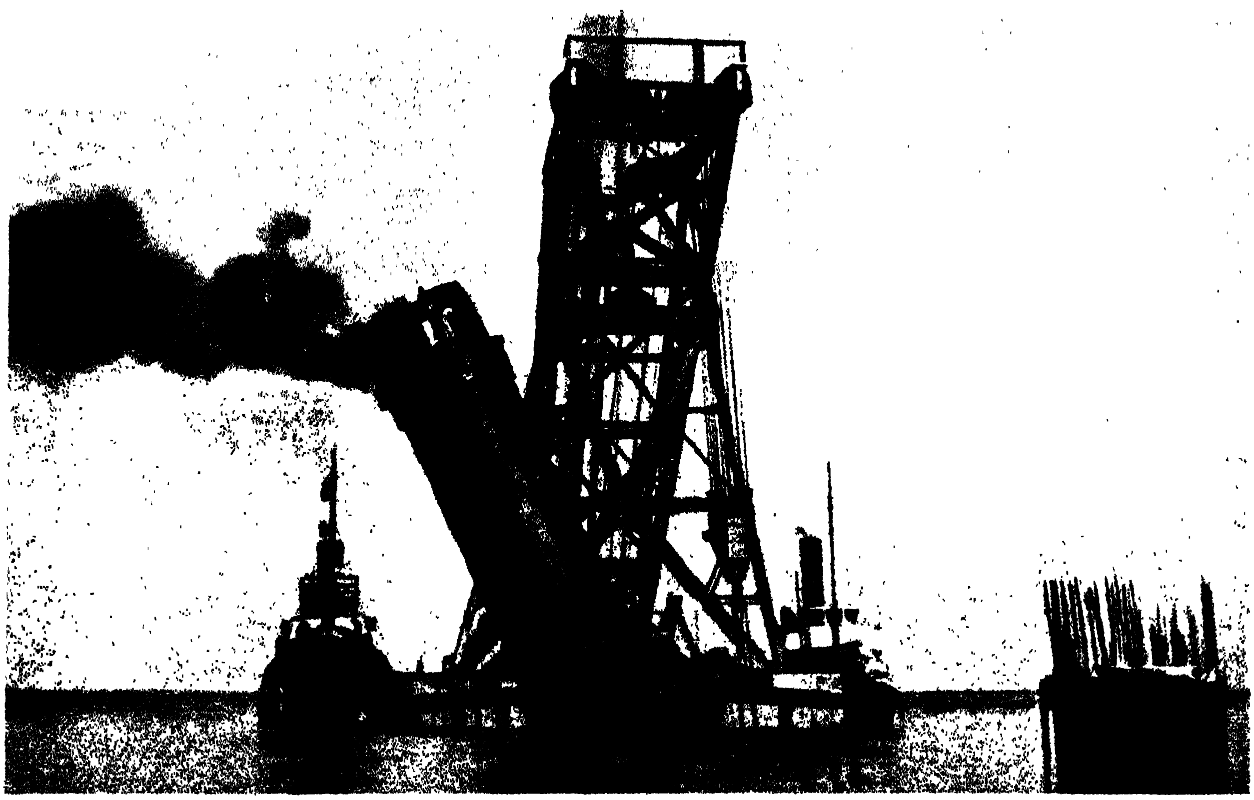
The Ancients, on the other hand, having no such power, had to use small quantities of force such as individual human beings could exert and use a large number of units over an extended period.

Thus, it is believed that the lintels or horizontal stones at Stonehenge were raised and placed upon the uprights by building round the upright pillars large mounds of earth. The lintels were then dragged up the slopes of these mounds till they stood on the two uprights, and finally vast labour was entailed in digging away the earth till the three stones stood isolated.

Three methods are adopted in the working of cranes. Sometimes there is a direct pull by a piston rod, but this, of course, gives only a very short range of lift. Then there is an indirect pull through a system of pulleys, and this is the method used in large hydraulic cranes, such as we see in operation at the quayside. A third method is to give an indirect pull by means of a rope or chain that winds on or off a rotating barrel. This type of crane is seen on railways.

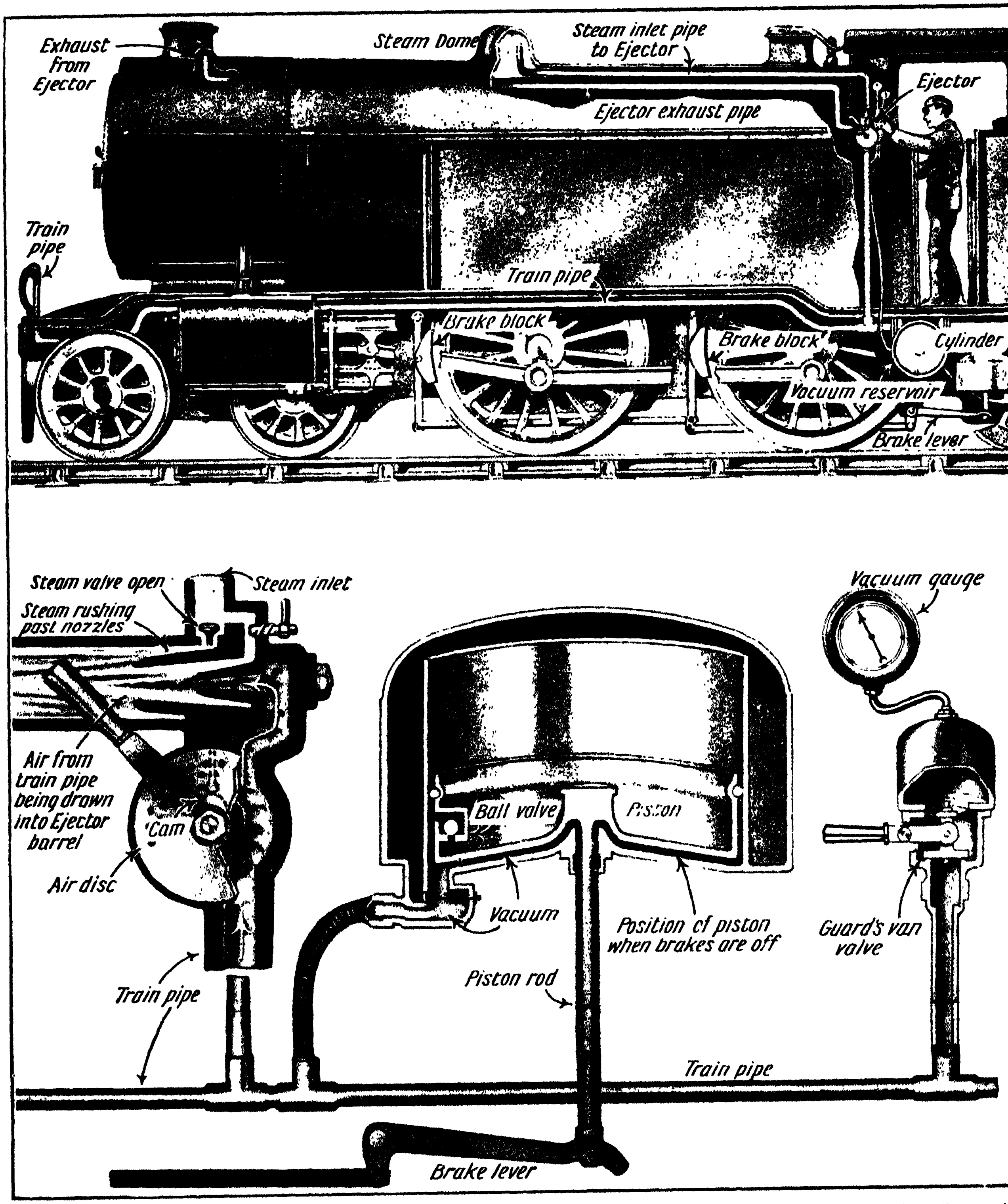
In movable cranes that are worked by steam the boiler is usually placed well out on the side opposite to that on which the pull is exerted, so that it may act as a counterweight and prevent the crane from being pulled over by its load.

The great overhead cranes that are found in engineering works, which lift sometimes more than a hundred tons at a time, are generally worked by electricity. Electric cranes are also used with grabs to unload coal or ore or ballast from the holds of ships.



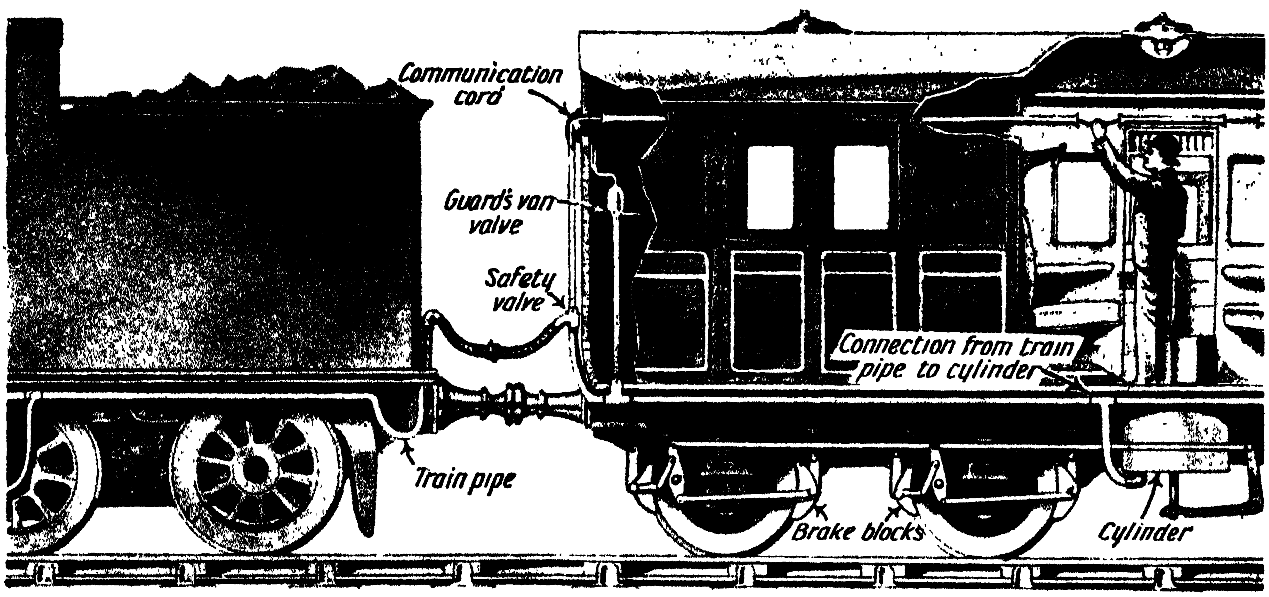
A floating crane at Bordeaux harbour lifting a heavy iron caisson and swinging it into position for lowering into the river-bed

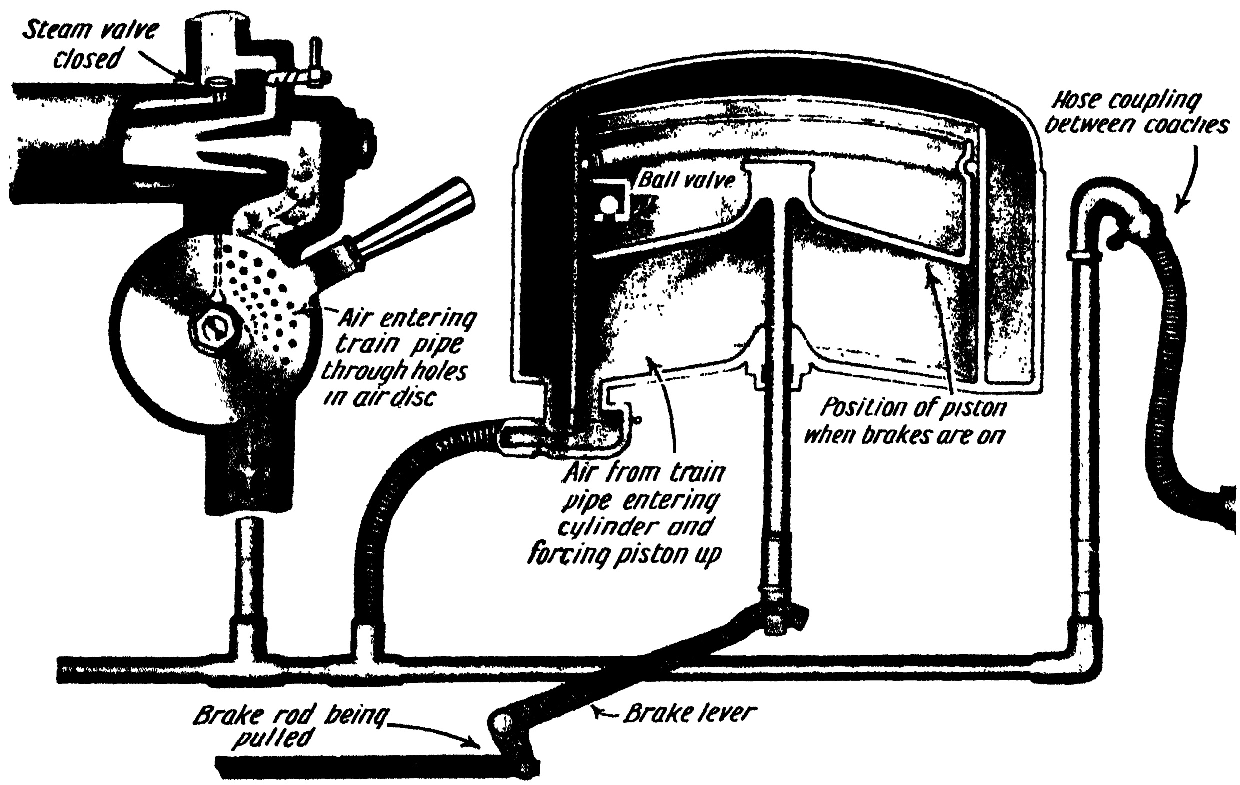
THE VACUUM BRAKE OF THE RAILWAY:



In this picture the artist explains in a simple way how the vacuum brake of a train is applied by the turning of a handle or the pulling of the communication cord. The locomotive and part of the first railway carriage of a train are shown. Under each coach and also under the engine there is a cylinder with a movable part inside called the piston. Each cylinder throughout the train is connected with the train pipe, the connections between the various coaches and the engine being made by means of hose couplings. The train pipe is connected to an ejector on the engine, which has a handle and by moving this the driver puts on the brakes of all the coaches. The ejector is shown on a large scale in the bottom left-hand drawing. It is connected with a steam pipe, through which steam under pressure can be passed from the steam dome. When the handle is in the "brakes off" position, as in the bottom left-hand picture, a cam on the air disc holds up a rod and opens a valve, letting in steam, which circulates round the nozzles and rushes out through the ejector barrel into the ejector exhaust pipe. The rushing of this steam over and past the nozzles with such force causes the air to be drawn by suction from a cone-shaped nozzle, producing a vacuum. Air at once rushes from the train pipe into this nozzle until at last all the air is withdrawn from the train pipe and the cylinders. As soon as the air in the cylinder which was supporting the piston is withdrawn, the piston falls, letting down the brake lever and holding the brake blocks away from the wheels. When the handle of the ejector is

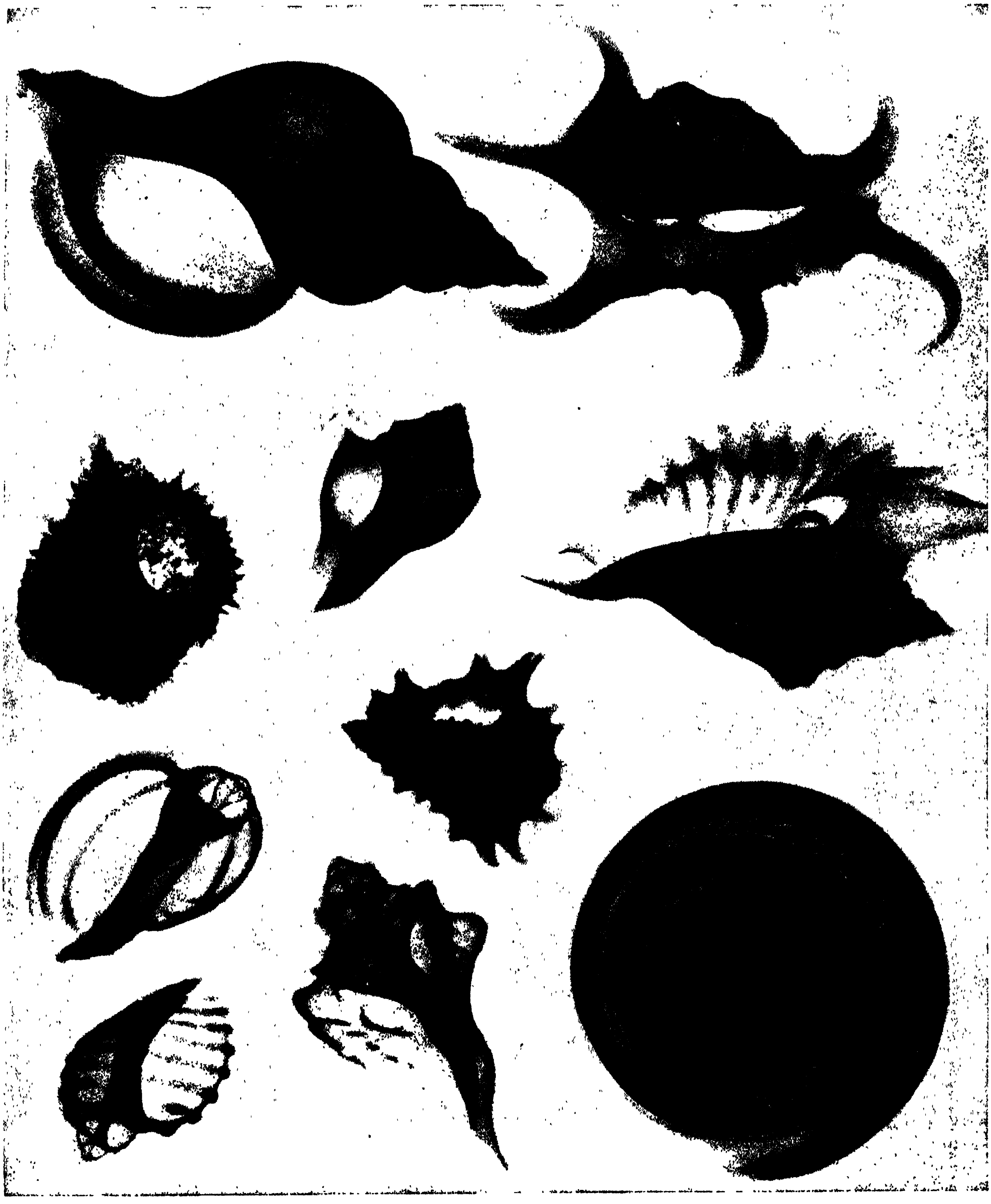
HOW IT IS ABLE TO STOP THE TRAIN





moved to the " brakes on " position, as in the right-hand bottom picture, the cam closes the steam valve and the holes in the air disc come over the train pipe. Air at once rushes through these holes into the train pipe, which then no longer contains a vacuum. The air passes up into each cylinder, where it forces up the piston, and in doing so pulls up with it the brake lever and draws the brake blocks on to the wheels. A ball valve preserves a constant vacuum above the cylinder and allows the air to be drawn into the train pipe, but will not allow it to go back again. An enlarged view of the guard's van valve at the end of the coach is shown. This is also connected with the train pipe. When the handle of this is depressed it opens a valve, allowing air to rush into the pipe, destroying the vacuum in all the cylinders and causing the brakes to be put on. Similarly when the communication cord in a railway carriage is pulled by a passenger a safety valve is pulled open at the end of the coach allowing air to rush into the train pipe and putting on the brakes. Should a coach become detached from the train on an incline the hose couplings would be severed, and this would mean that air would rush into the pipe, destroying the vacuum and applying the brakes to all the coaches. These brakes will stop the train, even if the engine is under full steam. It will be seen, therefore, that the vacuum brake is a very valuable appliance indeed, and to it in a very large measure we owe the safety with which we are able to travel on the railway. Hundreds of thousands of lives depend on it every day of the year

WHAT THE INSIDE OF A SHELL IS LIKE



It is difficult as we look at the outside of a shell to realise what the inside is like. Often the chamber is spiral-shaped, and the soft creature which inhabits it curls itself round in its home. Here are X-ray photographs of a number of different shells, and these will give us some idea of the interiors. The shells, reading from the top left-hand corner, are, in the first row, those of the common whelk and the scorpion shell ; in the second row, the murex, the pheasant shell, and the strombus; in the third row, the harp shell and another type of murex ; and in the bottom row, the dolium, the fusus and the trochus or peg-top shell. It is marvellous when one sees the immense variety and beauty of the shells found in different seas of the world, to think that these are all made by lowly creatures from lime and other materials extracted from the sea water and wrought into various colours and designs

THE GREAT SOUTH SEA BUBBLE

A good many people seem to think that the age in which we live is particularly notable for speculation and gambling. But although in these days there are plenty of people who want to get rich quickly without working, there has never been such a mania of speculation as took place in the eighteenth century, when millions of pounds were lost in what has come to be known as the South Sea Bubble. Here is the story of this mania

ANY commercial scheme which attempts to draw money from the public by dishonest promises, or any company whose shares are by fraudulent or shady means quoted at a price far in excess of what they are really worth, is spoken of as a "bubble."

It was Dean Swift, the author of that famous story, "Gulliver's Travels," who first used the name "bubble" in this sense, and it was the South Sea Company, a corporation which had been given by the English Government the exclusive right to trade with the Spanish coasts of South America, that was christened by him the South Sea Bubble.

"Bubble" is an excellent name for such dishonest business concerns, for just as a bubble that is blown bigger and bigger bursts at last, these businesses inflate the price of their shares until at last they get so huge that people begin to suspect them, and then the price comes down with a crash, just like the bursting of a great bubble.

The early part of the eighteenth century was a time when people had a mania for getting rich quickly. In this respect it was not unlike the days in which we live. People relied far more on gambling than on hard work to get on in life, and just as in recent years people have contributed millions of pounds to sweepstakes and questionable commercial concerns in the hope that tens of millions might be won in return for no work, so the same kind of thing went on early in the eighteenth century.

The greatest and most famous of all the get-rich-quick schemes was that which lives in history as the South Sea Bubble. The scheme began in a curious way, and at first the intentions of the promoters were honest, even if they were mistaken

Horror of a National Debt

Those were the infant days of the National Debt, and statesmen had a great horror of the nation incurring any debt at all. They feared the debt would go on increasing so that in the end it could not be repaid.

When Queen Anne came to the throne in 1702 the National Debt amounted to £16,000,000, and at her death in 1714 it had increased to 52 millions. This increase was caused by the wars in which John Churchill, Duke of Marlborough, won his great victories. We all know about the battles of Blenheim, Ramillies, Oudenard and Malplaquet. They stand out on the page of history as among the most brilliant victories won on the continent of Europe. But after the cheering is over wars always have to be paid for, and so in Anne's short reign of twelve years the National Debt had increased by £36,000,000

It is not surprising, therefore, that in those early days of the eighteenth century the National Debt was looked upon as an object of dread. Nevertheless, it is interesting to speculate what the statesmen of Queen Anne's and King George the First's days would say if they could return to the scenes of their exploits and learn that two centuries later the National Debt had increased to over 7,500 million pounds!

Now all this talk about the National Debt may seem to have little connection with the South Sea Bubble, but as a matter of fact the connection is very close

The South Sea Company was formed in 1711 in Queen Anne's reign by Robert Harley, Earl of Oxford, who was the Lord High Treasurer of England, and his object was to improve the public credit, for then, as now, people were very nervous about what was going to happen to their savings and to the money they had lent to the country, should the credit of the nation go down.

The scene in the City of London during the South Sea Bubble. From the painting in the National Gallery by E. M. Ward, R.A.

Ever since the days of Drake and Raleigh and the raids on the treasure ships of Spain, there had been a popular idea in England that the gold and silver mines of Peru and Mexico were inexhaustible, and that in order to get rich very quickly it was only necessary to trade with the Spanish colonies. If English manufactures could be sent out to the South American ports they would certainly be paid for a hundredfold in gold and silver ingots.

A report was very carefully spread about that Spain was willing to open four of her ports on the coasts of Chile and Peru for the purposes of English trade, and people who invested their money in the South Sea Company had visions of the immense wealth which was coming to them, just as people who buy a ticket in a sweeepstake always think they are going to gain a big prize, forgetting the millions of losers, who, if they formed a procession, would take many weeks to pass a given point.

But when the Treaty of Utrecht was signed which ended the Continental wars, it was found that Spain was not at all ready to open her ports to English trade. In fact, the King of Spain had never had any intention of allowing the English to do business with his South American possessions. The only concessions he would make were that the English might send one small ship once a year to trade with Mexico, Peru or Chile, the size of the ship and the value of the cargo being strictly limited. Further, he even gave the dreadful privilege, which was to last for thirty years, of supplying negro slaves from Africa to his colonies.

Royal Pickings

With regard to the one small ship of merchandise which was to be allowed to go to South America from England every year, even this was not without the condition that the King of Spain was to take one-fourth of the profits, and a twentieth of the remaining three-quarters.

However, people were so keen on getting rich quickly and were so deluded as to the vast hordes of gold and silver which they supposed were waiting in Spanish America, that nothing could undeceive them, and the shares of the South Sea Company went up very much in price

It was not till 1717 that the first annual ship made a voyage, and then in the following year war broke out again with Spain, all British goods in South America were seized, and of course trade ceased entirely. But still the foolish public thought there was a fortune waiting for everyone who could have a finger in the South American pie

When King George I opened Parliament in November, 1719, he said, addressing his faithful Commons, "I must desire you to turn your thoughts to all proper means for lessening the debts of the nation." And here comes in the connection between the National Debt and the South Sea Company.

In January the following year a proposal was read to the House of Commons from the South Sea Company offering to take over a large part of the National Debt, transforming the Government stock into stock of the South Sea Company.

The idea was very popular with large sections of the people, and the scheme would probably have been adopted almost at once, but that the Bank of England, which was the other great financial corporation of the day, offered better terms. Then the South Sea Company raised its terms, and after a great deal of squabbling a Bill was passed through both the House of Commons and the House of Lords enabling those to whom the nation owed money to take shares in the South Sea Company in place of their claim upon the nation.

Bankers who had lent great sums were ruined and had to shut up their shops and flee the country

Of course, the prestige of the South Sea Company was greatly increased by this deal, especially as, by clever manœuvres, the price of its stock was sent up by leaps and bounds. When we read the history of the South Sea Bubble we almost feel we are reading a newspaper account of some of the bubble companies and financial disasters of our own times.

All sorts of rumours favourable to the Company were circulated in order to send up the value of the shares.

The company of merchants trading to the South Seas would be the richest the world ever saw, and every £100 invested in it would produce hundreds of pounds a year to the stockholder. Perhaps it is not surprising that in a very short time the shares of £100 each were selling at £400.

A historian says that "it seemed at that time as if the whole nation had turned stockjobbers. Exchange Alley was every day blocked up by crowds, and Cornhill was impassable for the number of carriages. Everybody came to purchase stock. Every fool aspired to be a knave."

But now the shares began to go down again, and they fell as low as £290 each. The directors of the Company, however, were equal to this, and sent people among the crowds in the streets to gather little knots of listeners and talk about the enormous treasures of the South American seas. These tricks had their effect, and the slightest rumours sent up the stock once more higher and higher. One strange rumour was that the Spanish Government had agreed to exchange Gibraltar for some places on the coast of Peru, and that the South Sea merchants would be allowed to build as many ships as they liked and carry on trade without having to pay anything at all to the King of Spain.

Money Madness

When the speculating fever was at its height the directors of the Company opened their books for a subscription of a million pounds, but they would only sell the shares at £300 for every £100 of actual capital on the books.

People went absolutely mad. They could not subscribe fast enough. The streets were blocked, desks and tables and chairs were brought out in the roadways so that people might fill up their forms, and it is said that a hunchback allowed his poor bent back to be used as a desk at so much per customer.

In a very short time two million pounds' worth of stock had been subscribed. In a day or two each £100 share stood, not at £300, but at £340.

Then the directors declared that they were going to increase the midsummer dividend from 6 per cent. to 10 per cent., and that all new subscribers would be entitled to this return on their money. The unfortunate public took the bait, and when the directors opened another subscription for a million pounds, in which each £100 worth of stock had to be bought for £400, a million and a half pounds were subscribed within a few hours.

The great financial bubble was blown bigger and bigger. Joint stock companies started up everywhere. They were called bubbles by the few sensible people that remained, but nothing could undeceive the public with its visions of easily-won fortunes. Every evening, we are told, produced new schemes, and every morning new projects. The most exalted of the

aristocracy were as eager in this hot pursuit of gain as the most humble and plodding citizen. The Prince of Wales became governor of one company, and is said to have cleared £40,000 by his speculations.

Some of the schemes sounded reasonable enough, but others seem more like intentional jokes. Nothing, however, was too ridiculous for the public to swallow. One of the projects was for the establishment of a company to make deal boards out of sawdust; another with a capital of £1,000,000 was for a perpetual motion machine; another to fish up wrecks off the Irish coast; another to make salt water fresh; another for extracting silver from lead; another for changing quicksilver into hard metal; another for importing jackasses from Spain; another for fattening hogs; another for improving gardens. But perhaps the strangest of all was "a company for carrying on an undertaking of great advantage, but nobody to know what it is."

The treasurer of the company packed up his books and embarked in disguise on a small boat in the Thames

The Height of Folly

It seems difficult to think that there can have been people foolish enough to give their money to promoters of such a scheme. But the man who invented the swindle knew what he was about. He declared in his prospectus, or statement, that the capital required for this undertaking was £500,000, which was to be divided into 5,000 shares of a hundred pounds each. Each investor was to deposit £2 per share, and upon doing this he would at once become entitled to £100 a year Nothing was said as to how this immense profit was to be obtained, but the subscribers were told that they would have to wait a month for full particulars, when the remaining £98 of each share would fall due.

At nine o'clock on the morning after the prospectus was issued an office was opened for the bubble company in Cornhill, and all day long queues lined up and crowds fought to be among the first to get in. At three o'clock the office was closed for the day, when it was found that no fewer than 1,000 shares had been subscribed for and the deposit on each paid. The gentleman who planned the company had thus in six hours secured £2,000, and with this he decided to be content. So he set off the same evening for the Continent, taking the money with him, and was never heard of again.

No wonder Dean Swift, comparing Exchange Alley in London with a gulf in the South Seas, exclaimed:

> Subscribers here by thousands float,
> And jostle one another down,
> Each paddling in his leaky boat,
> And here they fish for gold and drown.

Still the swindles became more impudent. What were known as "Globe Permits" were issued, at prices up to 60 guineas each, and there was quite a rush to obtain them. They were square pieces of playing card, with the impression of a seal in wax, bearing the sign of the Globe Tavern, near Exchange Alley, and the inscription "Sail-Cloth Permits." The purchasers were told that the cards gave them permission to subscribe at some future time to a new sail-cloth manufactory, projected by one who was then known to be a man of fortune.

No doubt many people had an idea that the schemes were frauds, but they subscribed in order to become owners of shares which were going up all the time, and which might, in a few days or weeks, be sold at enormously increased prices to other dupes Indeed, buying and selling went on together, and so wild wa the confusion of the crowds in and about Exchange Alley that shares in the same bubble company were sold at the same instant at a far higher price at one end of the Alley than at the other.

Sir Robert Walpole, the statesman, foresaw the end of all this, and was greatly alarmed, and the King published a proclamation forbidding brokers to buy or sell shares in bubble companies, and threatening prosecution to those who did.

But South Sea stock went on rising, and in four days it leaped from £550 to £890. Many people began to feel that it could rise no higher, and they hastened to sell each £100 of stock for £890. So many sellers were there now and so few buyers, that in one day the stock fell from £890 to £640, and the directors became greatly alarmed. To send up the price once more they gave instructions to their agents to buy up shares, and this restored confidence, and by evening the stock had advanced to £750. It continued at this price for nearly a month, and then began to go up again till at last each £100 share was quoted at the enormous price of £1,000.

But soon the price began to go down again, and a month later it was only £700

At last the bubble burst. Attempts were made to persuade the Bank of England to circulate the South Sea Company's bonds as though they were bank notes. But the Company's stock went on falling, and many goldsmiths and bankers who had lent great sums upon the security of South Sea stock were ruined and had to shut up their shops and flee the country

The treasurer of the Company, a man named Knight, packed up his books and documents and embarked in disguise on a small boat in the Thames Thence he proceeded to a vessel hired for the purpose, and was soon safely in Calais.

Thousands Ruined

And now the vast extent of the fraud that had been practised on the public was made plain "Thus were seen," says a Parliamentary history of the time, "in the space of eight months, the rise, progress and fall of that mighty fabric, which being wound up by mysterious springs to a wonderful height, had fixed the eyes and expectations of all Europe, but whose foundation being fraud, illusion, credulity and infatuation, fell to the ground as soon as the artful management of its directors was discovered."

Thousands were ruined. One man who, in the pride of speculation, had said that he would feed his horse upon gold, was reduced almost to bread and water himself.

When inquiry came to be made it was found that even the Chancellor of the Exchequer and other members of the Government had shared in the plunder.

Those who, when they believed they were going to multiply their fortunes by ten, had lauded the directors of the South Sea Company to the skies, now cried out for their blood.

Some of the fraudulent promoters and friends of the scheme were brought to trial, but few were punished. A portion of the money was recovered, and in the end subscribers received about one-third of the nominal value of their shares. But, of course, the millions which people paid when the shares were sold at four, five and ten times as much as their price in the Company's books were entirely lost.

Naturally, it was a long time before public credit was restored, and although there have been times of mad speculation since, there has been nothing quite so extensive as the South Sea Bubble.

DOMESTIC ANIMALS THAT CHEW THE CUD

When visiting or passing through the country we cannot help noticing that the cows and sheep in the fields, when standing or lying still, are constantly moving their mouths as though chewing food. As a matter of fact, that is what they are actually doing. They belong to a group of animals that are called by men of science ruminants, and the word means "an animal that chews the cud." When the animals are moving their mouths in this way we say they are "chewing the cud," "cud" being only another word for the food which they are masticating. Here we see cattle in a field chewing the cud as they stand among the grass after grazing

These sheep are feeding and many of them also are chewing the cud. Animals which are vegetarians have to eat a much larger quantity of food than those animals whose food consists of flesh. Consequently their digestive organs are differently constructed. As we see on page 919, the stomach of a ruminant consists of four compartments. The food is taken in large quantities, stored up, and then masticated by the animal at its leisure. The cow, sheep, goat, camel, deer and antelope are all ruminant animals

WHY COWS AND SHEEP CHEW THE CUD

Why do cows and sheep chew the cud, while animals like dogs and cats do not do so? It is all a question of diet, and the digestive organs of the animals and their habits are adapted to the kinds of food they eat. This curious matter is explained on this page

The bodies and organs of living creatures are wonderfully adapted to their needs. This is well illustrated in the case of the digestive apparatus of mammals. Those animals that live entirely on flesh and as a consequence are known as carnivorous, from the Latin word carnis, meaning flesh, have comparatively simple digestive organs. The food goes direct into the stomach, is quickly digested by the juices there produced and its nourishing parts are absorbed by the body, while the refuse is passed off.

On the other hand, the digestive organs of the ruminants, that is the animals that live on vegetable matter and chew the cud, are very different, as we can see from the picture of the composite stomach of a sheep given on this page. There is a very small quantity of nutritious matter in proportion to the bulk of vegetation which they consume, and so a much more complicated apparatus for digestion is needed. Here the stomach, instead of being a single chamber, is fourfold.

When a cow or sheep nibbles off the grass in the meadow, it passes down the gullet from the mouth into the first compartment or largest of the four stomachs, known as the paunch or rumen. There it is softened by moisture for some time, and finally passes into the second compartment known as the reticulum or honeycomb. This is given the Latin name reticulum, meaning "a little net," because it has inside a network of small cells.

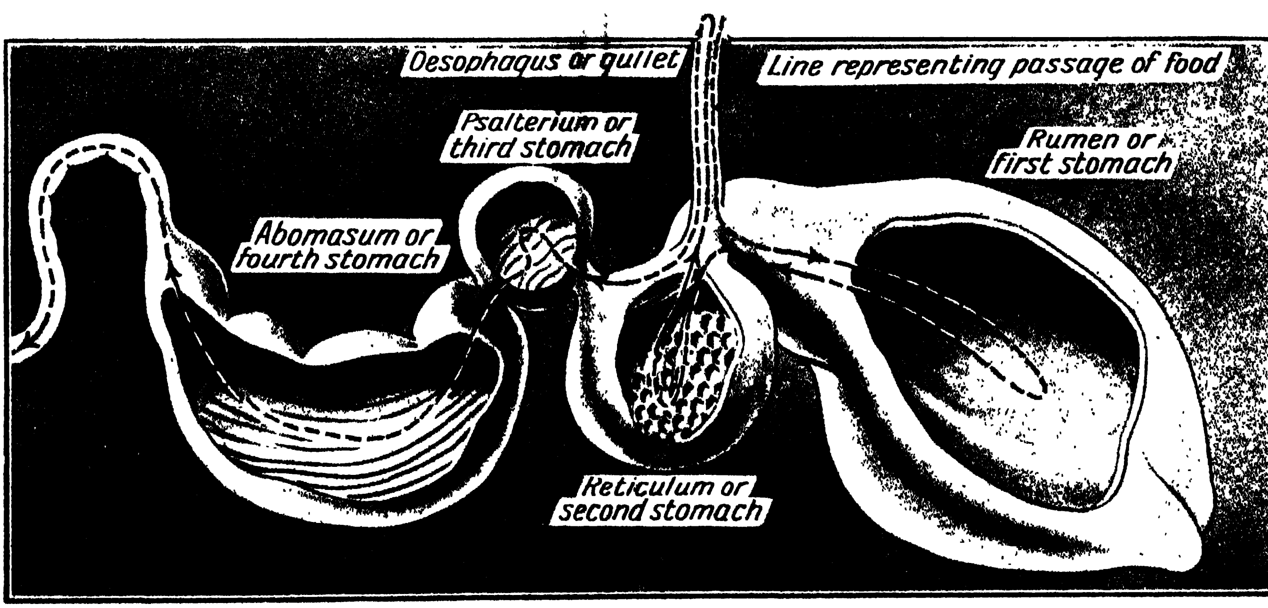
Here the process of softening is continued, and then the reticulum forces the food up the channel into the mouth once more. The animal now chews it again and again till it is much more finely minced, and when we see a cow or a sheep in a field constantly moving its mouth this is what it is doing.

A Wonderful Process

The food is now swallowed a second time, and passes into the third compartment known as the psalterium or manyplies. The latter name is given because the compartment has many folds in its lining, and it is called psalterium because of a fancied resemblance of the folds to the strings of a psaltery or harp. This simply receives the semi-fluid food in order to pass it on to the fourth compartment known as the abomasum. The word means "from the omasum," that being the Latin name for the third stomach. This is very much like the simple stomach of the carnivorous animals and produces gastric juice which acts upon and finally digests the food. We might wonder why the freshly-eaten food passing down the œsophagus always goes into the paunch or first stomach, and why, when it is swallowed a second time properly masticated, it always passes into the manyplies or third stomach. Well, by a wonderful arrangement, when the animal swallows the coarse and bulky food and this arrives at the point where the œsophagus opens out into a channel joining the various compartments it, by its sheer size, opens the lips of a groove leading into the paunch.

When, however, the animal swallows for the second time smaller quantities of semi-fluid food which has been thoroughly chewed, the pressure is not sufficient to open the groove into the paunch, and so it passes the other way into the manyplies.

The alimentary canal or intestine of an animal that chews the cud is exceedingly long; in a sheep it is 28 times the length of the body. This is to allow the food to come in contact with a very large extent of absorbing surface, so that the maximum of nutritious matter may be abstracted from it. In man the alimentary canal is only about nine times the length of the body.



Here we see how the stomach of a ruminant animal that chews the cud has four compartments. The herbage, when eaten, passes down the gullet into the first compartment, called the rumen or paunch. After being moistened it passes into the second compartment called the reticulum. There it is further softened, and is forced up into the mouth once more, where the animal masticates it again till it is finely minced. It is then swallowed a second time and passes into the third compartment or psalterium. At last the food goes into the fourth compartment, or abomasum, where it is finally digested

HOW A SEEDLING FINDS ITS WAY

No matter in what position a seed may be planted in the ground the root when it sprouts always grows downward into the soil, and the shoot that will become the stem and leaves grows upward towards the sunlight and air.

Of course we cannot see the plants germinating in the ground, but by a simple experiment we can watch for ourselves how they behave.

If we take a lamp chimney and fill it with wet peat moss or sawdust, and then place some beans in different positions round the side, so that we can see them, we shall be able to watch the way they grow.

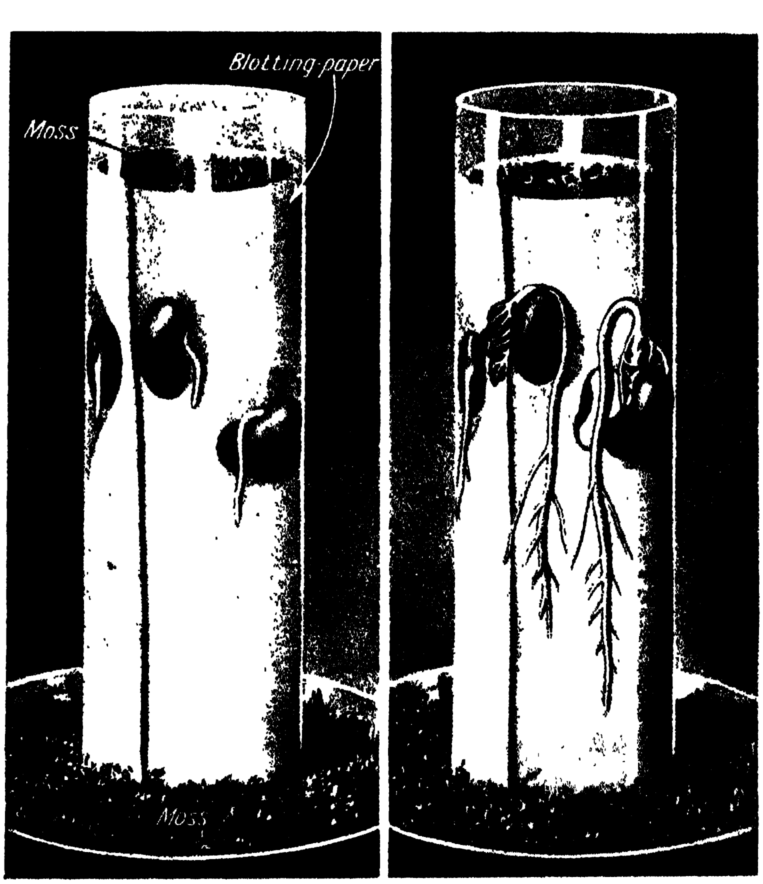
A good scheme is to roll up a cylinder of white blotting-paper and place this in the glass, putting the peat moss inside but not very tightly. Then we push the beans into position between the glass and the paper with a piece of wire. Before they are planted they should be soaked in water for from twelve to twenty-four hours. They absorb water and become larger, and the coat becomes wrinkled.

Signs of Life

After a few days in the glass signs of life appear. The root begins to grow out of the hollow or concave side, and no matter in which direction this is pointing, the root immediately starts growing downward.

Then the two halves of the bean swell, the outer coat cracks and begins to slip off, and the stem grows upward. After a time we can see that the stem growing up is the continuation of the root growing down.

The bean is only a familiar example of what happens in the case of all seeds—peas, acorns, and so on.



A simple experiment that enables us to see how a seed germinates and develops into a plant. We place beans in a lamp-glass which is filled with damp moss wrapped in blotting-paper. Every stage of the growth can then be followed

Now how is it that the baby plant is able to find its way up and down? The root never grows upward and the stem never grows downward into the ground. If they come out of the seed pointing in the wrong direction they at once turn round and take the right road.

Well, men of science tell us that plants, like ourselves, are able to perceive the pull of the Earth. We always know which end of us is up and which is down, and in the same way the plant has a sense of direction.

This is believed to be due to the fact that the tiny cells in the growing tips of the plant contain loose granules of starch, and these always lie on the side of the cell which is toward the Earth. The plant only grows normally when the starch grains lie on the proper side of the cell.

If the seed is planted in the wrong position and the green shoot comes out sideways, at once the starch grains in the cells of the growing tip find themselves in the wrong position. The cells at once start growing crooked, so that the starch grains may take up their right position, and lie on the correct side of the cell. Before long the whole shoot has adjusted itself, and then the growing upward continues. The same is true of the root cells, only in the opposite direction. Here the normal position of the starch grains is at the forward end of each cell, which, as the plant grows, points downward. Should the sprouting seed lie in a wrong direction, so that the root comes out sideways or from above, in some way the cells alter their growth so that the starch grains may take up their normal position.

It is very ingenious, and we may all be thankful that the seeds do know so well how to grow. Otherwise probably nine-tenths of what we plant would never come up at all.

There is another interesting thing about seeds. We cannot live without breathing, neither can an animal, nor a plant. But the same thing is also true of seeds. We buy a packet of seeds, large or small, and turn them out on the table, and they look very dry, and certainly we should not say from appearances that they were breathing. But they are, and if we prevent them breathing, that is, if we place them where they cannot get oxygen, they will soon die. If, for instance, we placed them in a box or bottle from which all the air had been extracted and left them there, they would perish.

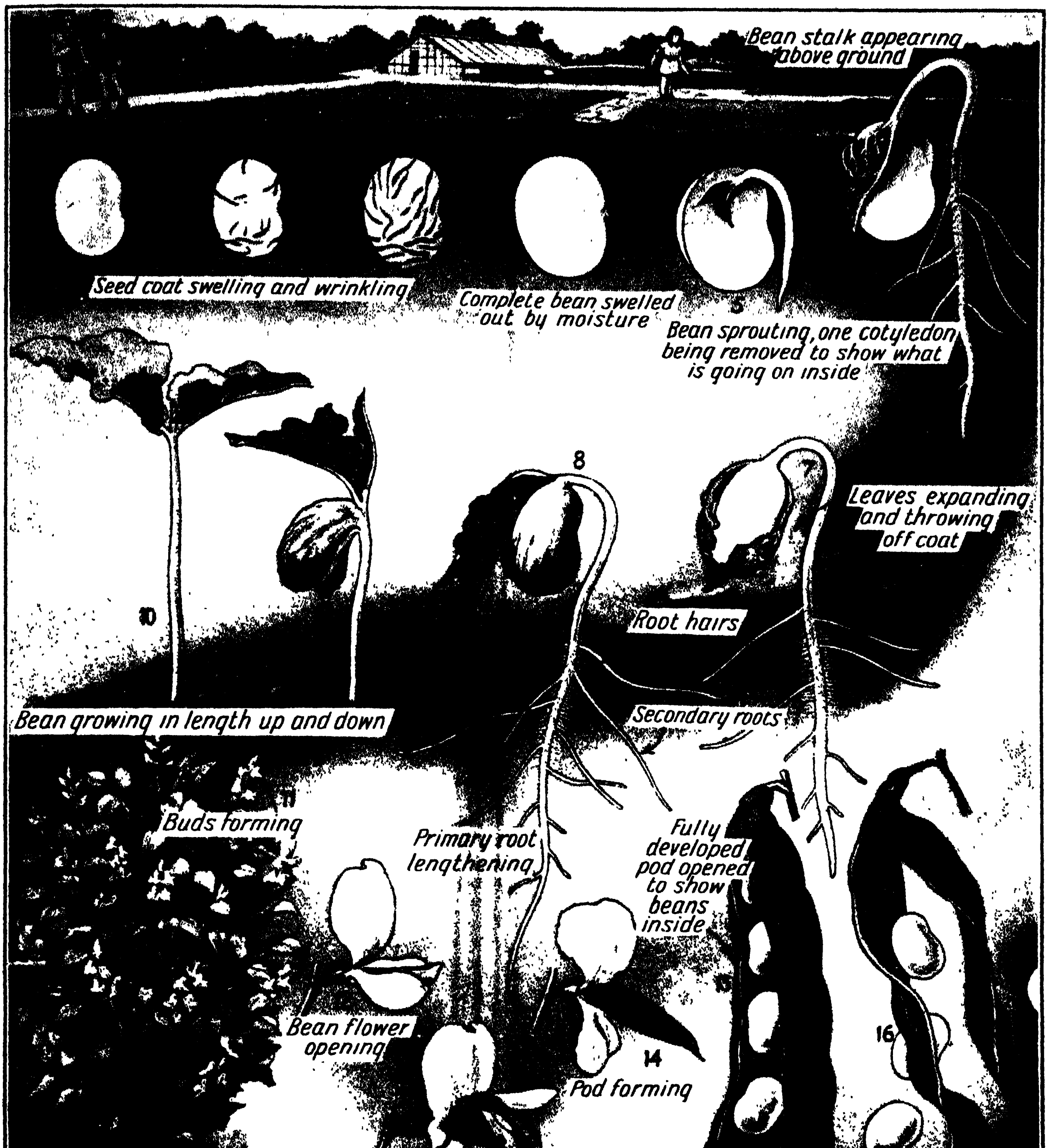
By means of very delicate apparatus scientists are able to measure the amount of oxygen which a dry seed breathes in. It is, of course, a very minute quantity, but small as it is, it is essential to the seed if later on it is to develop and sprout into a plant. When the seed is planted in the soil it, of course, breathes much faster than it did when it was dry in a box or packet.

Seed Experiments

There are, however, two plants whose seeds are exceptions. A Japanese scientist shows that rice grains, which are really the insides of rice seeds with the husks removed, will sprout in a sealed bottle from which all air has been withdrawn, and an American scientist has found a wild grass which grows in California, curiously enough as a weed in the rice fields, which does the same thing. But in both cases the seeds, in order to sprout, must be damp, and the explanation is that they get their oxygen from the water, so that in a sense they are no exception at all. All seeds must have oxygen if they are to continue growing.

All seeds have food stored up inside them to furnish nourishment to the embryo plant from the time it begins germinating until as a seedling it has established itself in the soil and can obtain food for itself from outside. Sometimes, as in the bean and pea, the food is stored up in the cotyledons or seed leaves, while in other plants, such as maize and wheat, the food is stored round or at the side of the embryo. In that case the part containing the food is called the endosperm, which means "the inside of the seed."

THE LIFE-STORY OF A COMMON BEAN



Here in this page we see the life history of a common garden bean. The beans which we see in the pods are really the seeds of the plant, and when put into the earth under suitable conditions will germinate and produce new plants. When a bean is planted its skin is tight and smooth, but it soon takes up moisture, and the coat swells and becomes loose, for it absorbs water faster than the embryo inside. After a time, however, the embryo also swells as a result of absorbing moisture, and the seed becomes plump once more. Then the part inside which will become the root gets longer and, piercing the seed coat near the scar, juts out. It grows downward into a long, slender, conical root on which many root hairs soon appear. The part which will become the stem and leaves, and lies between the cotyledons or two sides of the bean, also grows and travels upward, forming a loop and carrying the cotyledons with it. It develops leaves first of all, then buds, which open into flowers, and after these are fertilised a seed pod forms with the seeds or beans inside. This grows to its full size and, after ripening, the pod will dry and, unless harvested by man, throw out the beans on the ground, to start the life-story all over again. The various stages in the growth of the bean are numbered to show their sequence or order

THE GENTLEMAN IN A WHITE COAT

The polar bear is a very picturesque animal, and is always popular at the London and other Zoos. But it is not a pleasant creature to meet in its native haunts when it is hungry. It does not, like some wild animals, flee when it sees a man, and has often come up behind hunters while they were skinning seals and attacked them. The only chance for a man thus taken unawares is to pretend to be dead, when the bear retires to a distance watching the supposed body. The man then has a chance, if his weapon is near, of shooting the bear. In these pages we read many interesting things about the polar bear and its habits in the natural state

The polar bear is distinguished from all other bears by its white coat, and it is curious that unlike most white mammals it retains its distinctive livery at all seasons of the year. Explorers often speak of it as "the gentleman in a white coat"

Further, whereas other bears seem to have rather large heads, the polar bear's head appears too small for its body. Its neck also is longer than that of other bears, the ears are exceptionally small, and the soles of the feet have hair growing on them, which is a useful provision of Nature, for it enables the bear to walk and run easily over the slippery ice.

But while its head is small, the polar bear itself is one of the largest members of its family, and it often reaches a length of nine feet. A full-grown polar bear weighs six hundred-weights or more.

It is found right through the Arctic regions, and sometimes floats across the sea on an ice-floe and lands in Iceland. When this occurs there is a general hue and cry, and the polar bear is hunted till it is killed.

A Lover of Cold

It does not favour the haunts of man, and as certain regions of the Arctic become more populated the polar bear retreats. In Labrador, for example, it was at one time quite common, but is now rarely seen

It seems to love the cold, and lives on coasts and islands that are ice-locked for a great part of the year. It feeds upon the flesh of seals and walruses and white whales, and in certain districts consumes large quantities of fish, including salmon. It also eats such vegetable substances as seaweed, grass and lichen, and in summer lives principally on these.

Travellers in the far north often kill the polar bear for food, and if the animal is not too old its flesh is quite palatable. In taste it is something between pork and beef, and in colour resembles veal.

It used to be thought that the polar bear hibernated, but it is now known that this is not correct. The female, however, often retires to a "den" in the snow and remains there for weeks, where she brings forth her young She does not sleep or become torpid. She simply remains quietly in her retreat and lives upon the fat which she has accumulated in her body during the warmer months. This enables her not only to live herself, but to nourish her young. The males, however, do not retire, but wander about on the ice during the long polar night.

While the polar bears in their active state live round the coasts and often swim in the sea, the female when she retires for the winter at the beginning of October always goes some distance inland. She has one to three cubs at a birth.

Polar bears born in captivity seldom survive. The first polar cub reared in Britain was Brumas, born at the London Zoo, November 29, 1949, and named after her keepers, Bruce Smith and Sam Geddins (Sam being reversed).

The polar bear is not a pleasant animal to meet, and it is often very bold. A young bear once climbed aboard Nansen's ship the *Fram* by the gangway, seized a dog and carried it off the ship and over the ice, where it ate it Later it returned and took a second dog, and then a third. When chased by men and dogs it boldly faced them and then pursued and seized one of the men, Johansen, who had fallen on the ice.

A Narrow Escape

"I thought it was all up with me," says Johansen, "I had neither gun nor knife, but I took the lantern and gave him such a whack on the head with it that the thing broke and went flying away over the ice. The moment he felt the blow he sat down and looked at me. I was just taking to my heels again when he got up. I don't know whether it was to grip me again or what it was for, but anyhow at that minute he caught sight of another dog coming, and set off after it and I got on board." The bear was eventually shot from the ship.

Nelson once had a fight with a polar bear, when as a boy of fifteen he made a voyage to the Arctic regions. He had heard that two ships were fitting out for a voyage of discovery towards the North Pole, and took the post of coxswain

A polar bear swimming among the ice in Greenland waters

The vessels went on the expedition and were for a time imprisoned by ice. One night, during the mid-watch, young Nelson, taking advantage of a fog, stole away from the ship and set off over the ice with a single comrade in pursuit of a bear.

It was not long before he was missed, and as the fog had now thickened the captain and his officers were greatly alarmed for the safety of the boy and his companion. Between three and four in the morning the weather cleared, and the two adventurers were then seen at a considerable distance from the ship attacking a huge polar bear

A Daring Boy

At once the signal was made for them to return, and Nelson's companion drew his attention to it and begged him to obey. But the boy wanted to conquer the bear. He had fired at it, but the musket had flashed in the pan and the ammunition was exhausted.

"Never mind," he cried, "let me get a blow at it with the butt end of my musket, and we shall have it." He would undoubtedly have fought the bear with the musket, but fortunately for him there was a chasm in the ice which divided him from the animal, and this fact probably saved his life.

The captain of the ship seeing the danger of the young coxswain fired a gun, which had the effect of frightening off the animal. Nelson then returned, and was reprimanded sternly for his disobedience.

A female polar bear with her cubs in winter quarters beneath the snow. A passage leads to the air outside

The captain asked him what motive he could have for hunting a bear.

"Sir," said young Nelson, "I wished to kill the bear that I might carry the skin to my father."

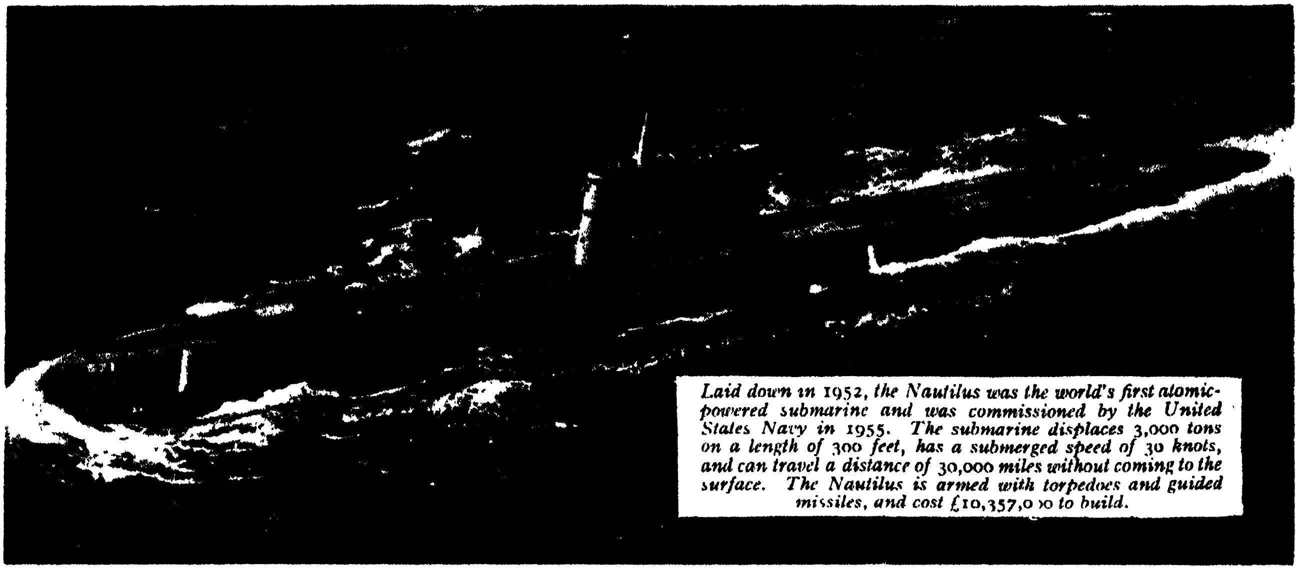
The Bear's Sagacity

Polar bears show a good deal of sagacity. The captain of a Greenland whaler was anxious to procure a specimen without injuring the skin, and he tried the stratagem of placing a noose of rope in the snow and putting a piece of meat within it.

A bear enticed to the spot perceived the bait, and seized it in his mouth, but at the same time its foot, by a jerk of the rope, became entangled in the noose. The bear was seen to push the rope off its foot with its other paw, and it then retired with the bait. The noose was baited a second time, and later the bear returned and carefully scraped away the snow and pushed the rope aside.

Polar bears are very playful, and at the London Zoo they like to have a ball or a tyre to play with in the water. Here we see one of the bears, known as Sam, catching a ball that has been thrown to him by a keeper

THE WORLD'S FIRST ATOMIC-POWERED SUBMARINE

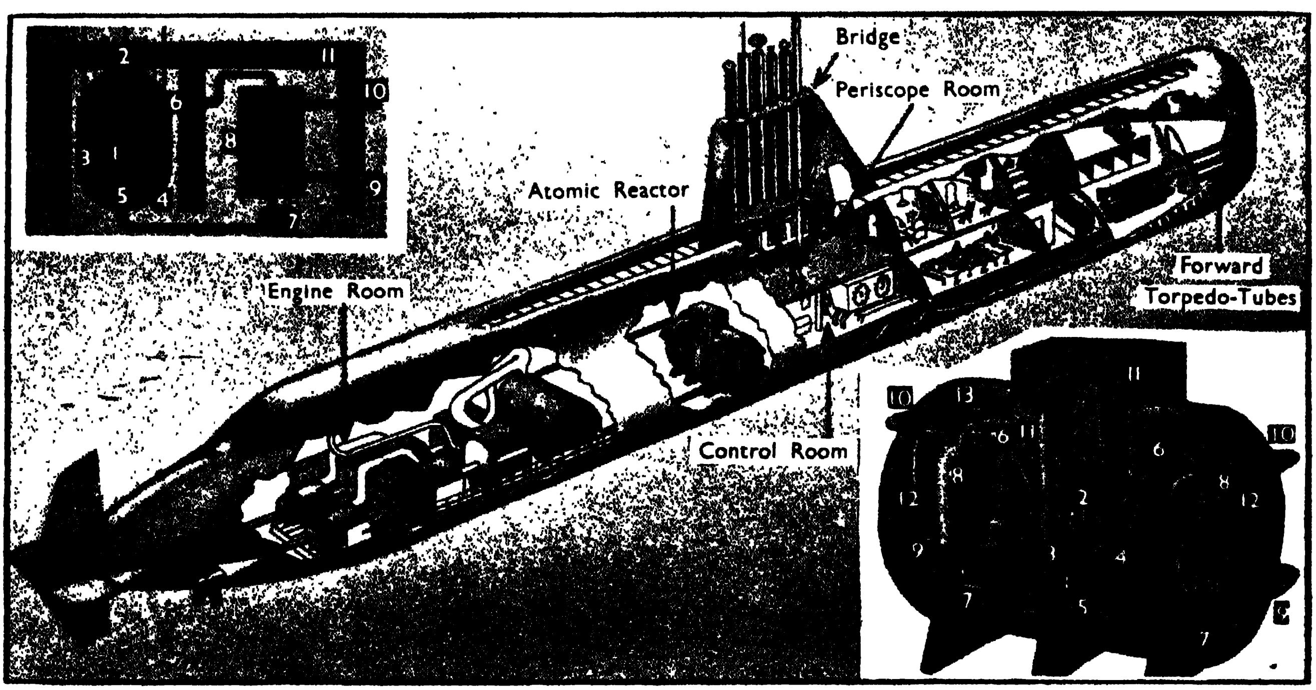


Laid down in 1952, the Nautilus was the world's first atomic-powered submarine and was commissioned by the United States Navy in 1955. The submarine displaces 3,000 tons on a length of 300 feet, has a submerged speed of 30 knots, and can travel a distance of 30,000 miles without coming to the surface. The Nautilus is armed with torpedoes and guided missiles, and cost £10,357,000 to build.

When an ordinary submarine is submerged it moves under water by means of electric motors taking current from storage batteries. The current lasts for only a few hours, even if the submarine is travelling at low speed, and in order to recharge the batteries the submarine must come to the surface. Recharging is from a generator driven by a diesel engine, which is also used to propel the vessel when on the surface. The diesel engine can be used to drive the submarine under water as the engine must breathe in air and breathe it out again ; and the air breathed out is carbon-monoxide gas which would poison the crew.

One method of supplying air to a submerged submarine's diesel engine and then carrying away the poisonous gas is to use a schnorkel tube which projects some distance above the surface of the sea. One part of the tube draws in fresh air and the other carries away the carbon monoxide gas. Unfortunately, a submarine using a schnorkel can move only a few feet below the surface, while the tube leaves a tell-tale wake which gives away to enemy ships the submarine's position below the surface of the water.

Because the production of atomic energy does not consume much air and does not release poisonous exhaust fumes, nuclear fission answered the problem of finding an engine that would operate continuously while a submarine was submerged at its maximum operational depth. In the Nautilus an atomic reactor is used to generate heat which in turn converts water into steam. The steam then passes through turbines which in turn revolve the submarine's propeller shafts. The reactor, and the screening necessary to protect the crew from the dangerous radiation emitted, are very similar to those of the atomic power station illustrated and described in pages 494–495, but on a much smaller scale. The photograph at the top of this page shows the atomic powered Nautilus at sea. The drawing below shows the interior of the submarine, and the smaller drawings the layout of the engine. 1, fuel elements ; 2, control rods ; 3, thermal shield ; 4, pressure vessel ; 5, pressurised-water inlet ; 6, pressurised-water outlet ; 7, circulating pump ; 8, heat exchanger ; 9, water inlet ; 10, water outlet ; 11, safety shielding ; 12, steam drier ; 13, reactor vessel or casing.



WONDERS OF THE SKY

THE EARTH'S PATH ROUND THE SUN

Every boy and girl now knows that the Earth travels round the Sun, and not the Sun round the Earth. But centuries ago even men of science thought the Earth was the centre of the universe, and that all the other heavenly bodies circled round it. Here we read the reasons why it is now known that it is the Earth that travels in an orbit round the Sun

The Earth travels round the Sun in a path that is almost, but not quite, a circle. It is known as an ellipse; but, of course, the path is not so elliptical as is shown in geography and astronomy books. There the ellipse is greatly exaggerated for the sake of convenience. If the figure of the Earth's path round the Sun be represented on paper as it really is, it appears to the eye as a circle, so little does it vary from a true circle.

If we can get the use of a schoolroom or other large apartment, we can draw on the floor an exact representation of the Earth's orbit. We need a floor space about 35 feet square. In the middle of the space we mark the centre, and on each side of this centre in a north and south direction we drive a small nail at a distance of an inch and a half. The two nails are thus three inches apart.

Now we take a piece of string of a kind which does not stretch easily and cut off 200 inches, tying the ends together so as to make a long loop of 94½ inches. One end of the loop we put round the nails driven into the floor. These nails project about an inch and a half for the purpose. With a chalk slipped into the other end of the loop we stretch the string taut and then walk round making a chalk line on the floor till we come back to the place where we started. The result will be an ellipse of exactly the same proportions as that of the Earth's path.

Now if we draw round the nail which is nearest the north a little circle eight-ninths of an inch in diameter, that will represent the Sun in the correct proportion to the Earth's orbit, and in its right position inside the orbit. The Earth to be represented to scale could hardly be drawn small enough; it would have to be only one twenty-fifth of an inch in diameter.

If, however, we can draw our orbit in the playground using a looped string 94½ feet, we shall then have to draw the Sun ten and two-third inches in diameter, and we can represent the Earth almost accurately by drawing a circle a fraction one-tenth of an inch in diameter. The greatest axis of the Earth's orbit is 186 million miles, and the distance round the orbit is 584,000,000 miles. To travel round this great path takes the Earth exactly 365 days, 5 hours, 48 minutes, 46 seconds, and on an average it travels at 18½ miles per second; which is much faster than the fastest supersonic rocket.

Nine Miles in Half a Second

This is a very great speed, as we may realise by a simple experiment. Hold a penny between the fingers at a height of 4 feet from the ground. Now suddenly let the penny drop. It will reach the floor in exactly half a second. Yet in that brief moment of time our Earth has moved forward in its orbit no less than 9¼ miles.

But its speed is not the same at all times in the year. The reason is that the Sun is not in the centre of the orbit. In winter the Earth is about three million miles nearer the Sun than it is in summer. This has been discovered by measuring the Sun's disc through a telescope.

It appears a little larger in winter than it does in summer. It is largest on January 1st and smallest on July 1st each year, and while from January to July the apparent size of the Sun gets gradually less, from July to January it increases. It is by making careful observations of the change in the apparent size that the exact form of the Earth's orbit is discovered.

Naturally, as the Earth is kept in its elliptical path by the attraction of the Sun, that luminary's pull is a little more powerful as the Earth approaches nearer to the Sun, and the speed is thereby increased.

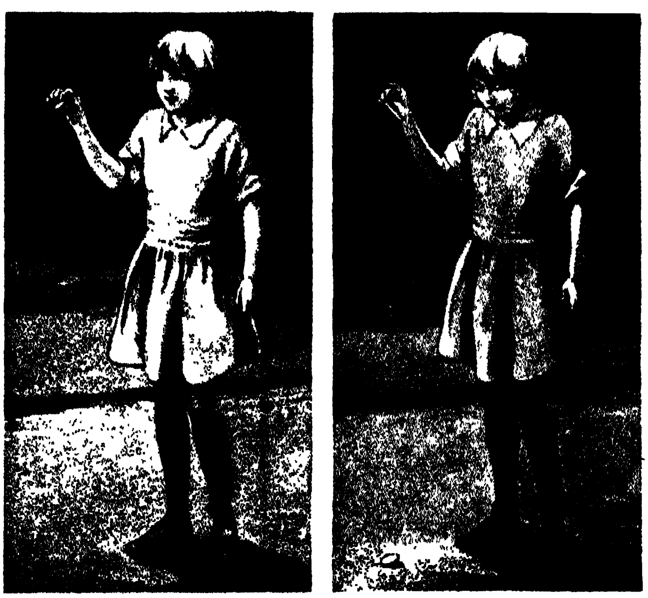
The Earth is nearest to the Sun during the southern summer, that is when it is winter in Europe, and as our planet then moves more quickly, summer in the Southern Hemisphere does not last so long as summer in the Northern Hemisphere. In the north it is seven days longer than in the south.

We live in a world of illusion; that is, we are deceived by what we see, and things are not at all as they seem. For instance, the ground on which we stand appears so very still, yet we know it is whirling round at many miles an hour, the rate varying according to the part of the Earth on which we stand.

Then the Sun seems to travel round the Earth, coming up every morning in the east and moving in a semicircle across the sky till it drops in the west, when it continues its journey and is seen by people on the other side of our globe. Yet, as we have seen on pages 561 to 564, the Sun does not travel round the Earth at all; it only seems to do so because the Earth moves round on its axis in every twenty-four hours bringing the Sun in view of every place on the Earth's surface in turn.

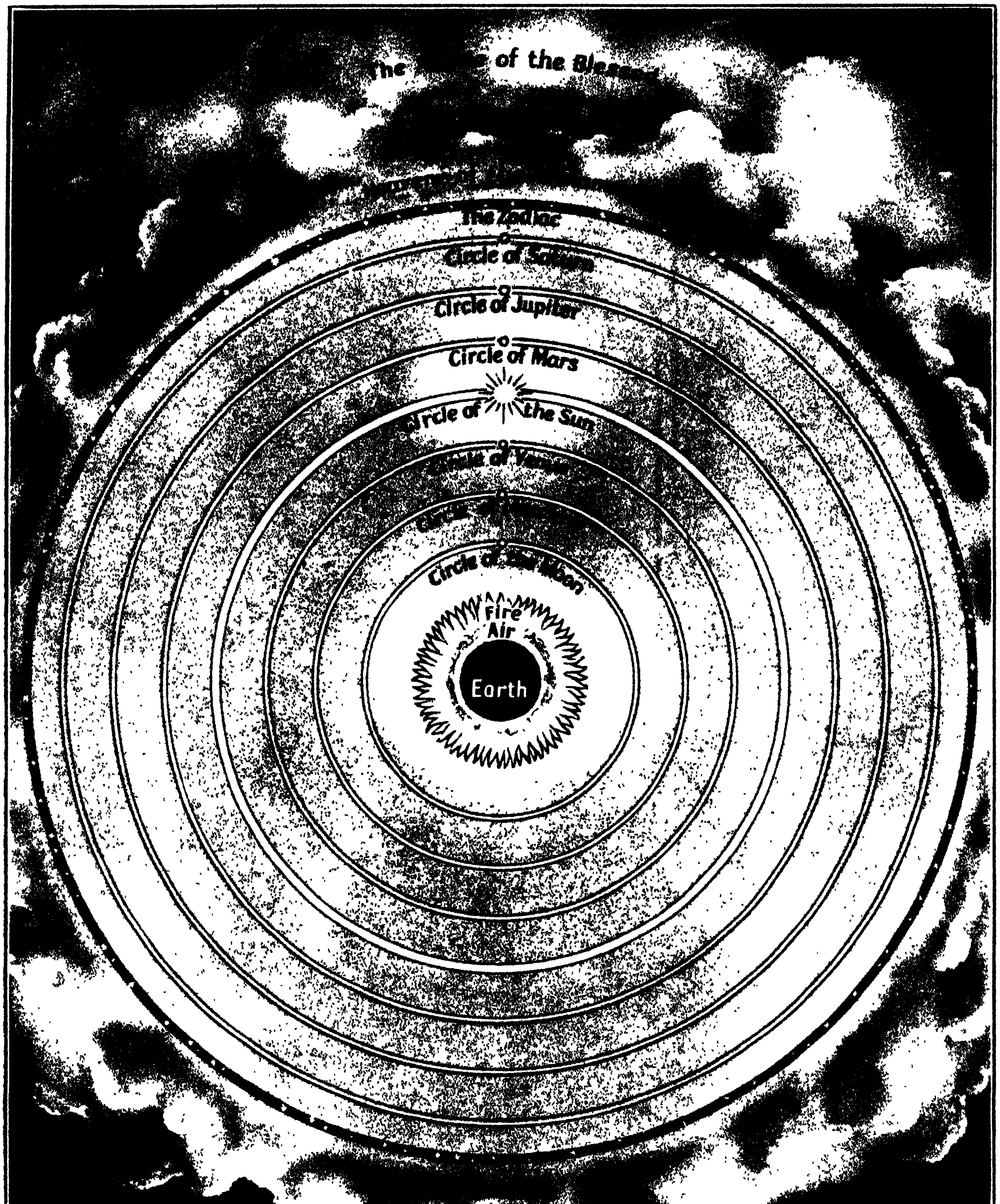
Another illusion we get, as we look up at the sky, is that we are in the centre of a great sphere and that the inside of this sphere is dotted with little points of light which we call stars. Further, if we watch these particular stars night after night, we get the impression that the celestial sphere is moving round us who seem to be at its centre.

But men of science have discovered that this is not the case at all. The supposed sphere with points of light fixed on its inner surface is really the vastness



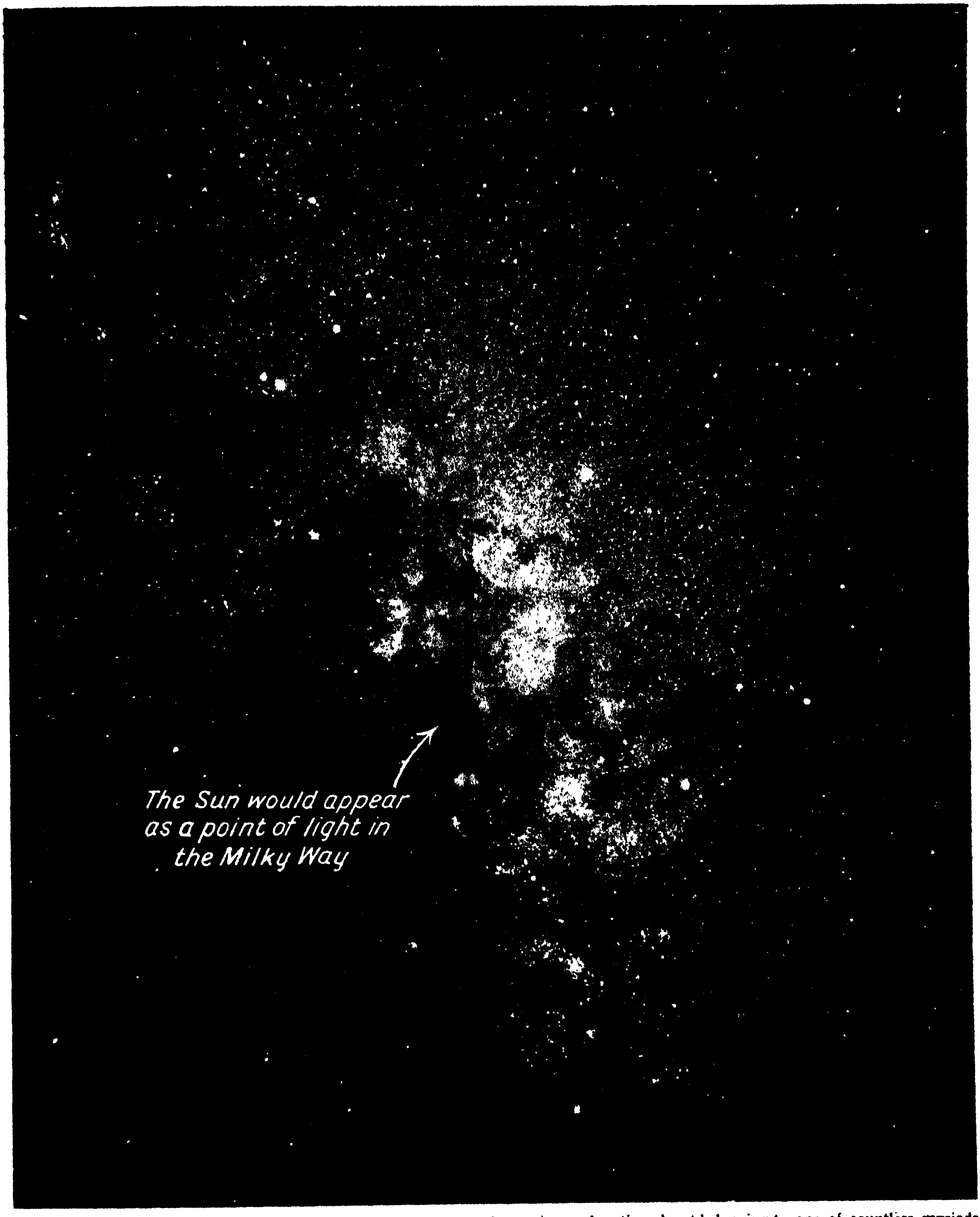
Here is an interesting experiment. Hold a penny four feet above the ground; then let it fall. It soon strikes the ground, but during the half-second in which it was falling you have travelled with the Earth in its orbit no less than nine and a quarter miles

HOW MEN USED TO THINK OF EARTH AND SKY



Hundreds of years ago men of science had very incorrect ideas about the Earth on which we live and the sky above us with its twinkling points of light. In this picture we see the Earth and heavens as conceived by the great Greek philosopher, Aristotle, and his ideas held the field for centuries. The Earth was supposed to occupy the centre of the universe, and round it was a sea of air. Outside this was a region of fire, and then the various heavenly bodies like the Moon, the planets and the Sun circled in heavens of their own. Beyond these bodies was the heaven of the firmament which contained the Zodiac, or twelve constellations, shown on page 153. Then came a crystalline heaven, and finally the heaven which was regarded as the abode of the blessed. On the page opposite we see the true idea of the universe, which is based not on theory or fancy but on actual observation

AN ACTUAL PHOTOGRAPH OF THE UNIVERSE



We now know that the Earth, so far from being the centre of the universe, is merely a tiny planet belonging to one of countless myriads of suns that are gathered into island universes and scattered throughout the vastness of Space. Our Earth and Sun belong to the Milky Way system, part of which is shown here in a photograph taken at Harvard College Observatory, and given by courtesy of that institution. If an astronomer could go to a point millions of millions of miles away in distant Space, and, with a giant telescope and camera, photograph our Sun, it would appear merely as a tiny point of light amid myriads of other similar points, all of which would be globes of fire, some larger and some smaller than our Sun. The Earth and planets would, of course, be too small to be seen at all

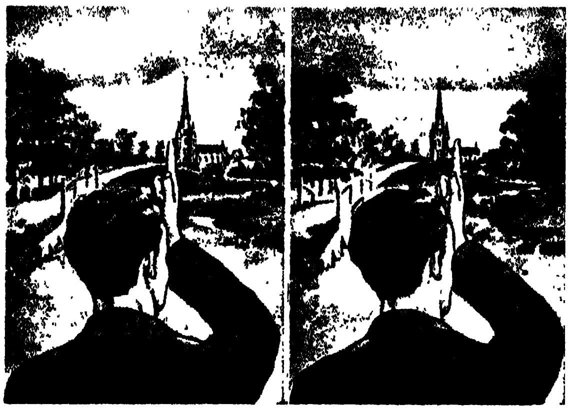
of Space, and the points of light are scattered about in Space, some of them hundreds of millions of miles away, some thousands of millions of miles, and others millions of millions of miles distant.

The motion of the stars that cross the sky, which suggests that the celestial sphere is moving round us, is due to the fact that our Earth is turning round on its axis once in every twenty-four hours. It is not surprising that men who studied the heavens used to think the Earth was the centre of the Universe, and that the Universe consisted of a huge hollow globe.

It was very early seen by astronomers that there were two apparent motions of the Sun—one his seeming journey round the Earth every twenty-four hours, and the other a journey round a certain line or band in the celestial sphere.

They believed in this latter motion because they noticed that at different times of the year different groups of stars were visible in those parts of the heavens across which the Sun moved in its daily journey. The zone or band in which the apparent annual path of the Sun in the heavens was situated was called the Zodiac, from a Greek word meaning "animal circle." In this zone or band there were twelve constellations or groups of stars, many of which were named after animals, like the Ram, the Bull, the Crab, the Lion, the Scorpion, the Goat, and the Fish. In the Zodiac the Sun, Moon and Planets are always to be found and the Sun's path is the central line of the zone. But in the course of thousands of years the position of the constellations has changed somewhat so that they do not now coincide exactly with the Zodiac.

We have now learnt that the reason different stars appear in the sky at different times is not that the Sun is moving in a circle through them, but that the Earth on which we live is moving in an almost circular path round the Sun, and that the Earth is tilted at an angle of about 23½ degrees to this path round the Sun.



This experiment will illustrate what is known as parallax. Look at a distant object like a church spire with both eyes and hold a finger immediately in front of it. Now close your right eye, keeping your finger still. The church spire appears on the left. When you close the left eye the church spire appears on the right. In the same way the stars appear in different positions when looked at from different parts of the Earth's orbit

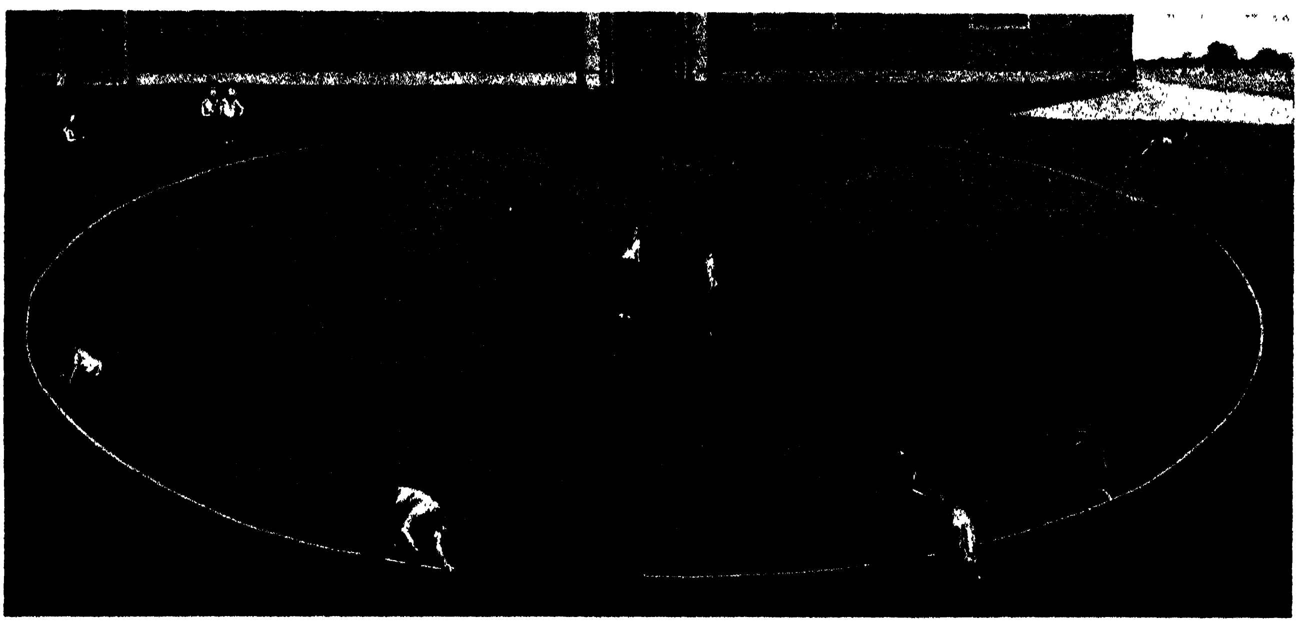
We cannot trace all the steps as knowledge grew, but we may consider the various reasons men of science have to-day for believing that the Earth moves round the Sun in a path or orbit that is not quite circular, and that the Sun is not quite in the centre of this orbit.

In the first place, according to the laws of motion which can be proved by experiment, two bodies which are both free to move revolve round their common centre of gravity. Now the Sun is more than a million times as big as the Earth, and its mass or weight is 330,000 times that of the Earth, while its diameter is some 867,000 miles. If then the Earth and Sun follow the laws of motion they will revolve round their common centre of gravity, which is a point very near the centre of the Sun. We see this on page 111. For this reason the Earth may be supposed to race round the Sun in an orbit, and all tests that can be applied prove it to be a fact.

Another proof that the Earth revolves round the Sun is furnished by what is known as the aberration of light. This is fully explained on pages 391 and 392.

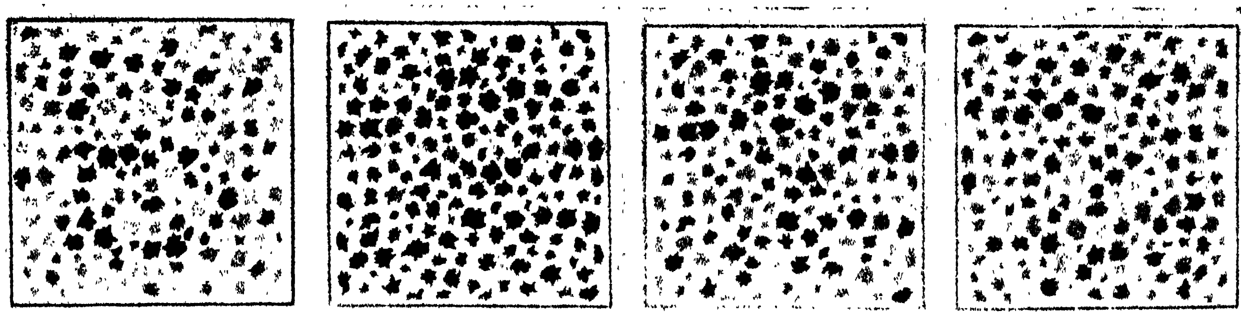
Another proof that the Earth travels round the Sun is provided by what is known as the parallax of the stars, that is that they appear in slightly different positions when viewed from different parts of the Earth's orbit. This is explained in the upper picture on this page.

Then the fact that the Earth is moving round the Sun travelling in one direction as it comes along one side of the orbit and then in the opposite direction as it comes round the other side of the orbit, is proved by observing the light of certain stars by means of the spectroscope. The dark lines of the spectra move differently according to whether we are travelling towards the star on one side of the orbit or away from it on the other side.

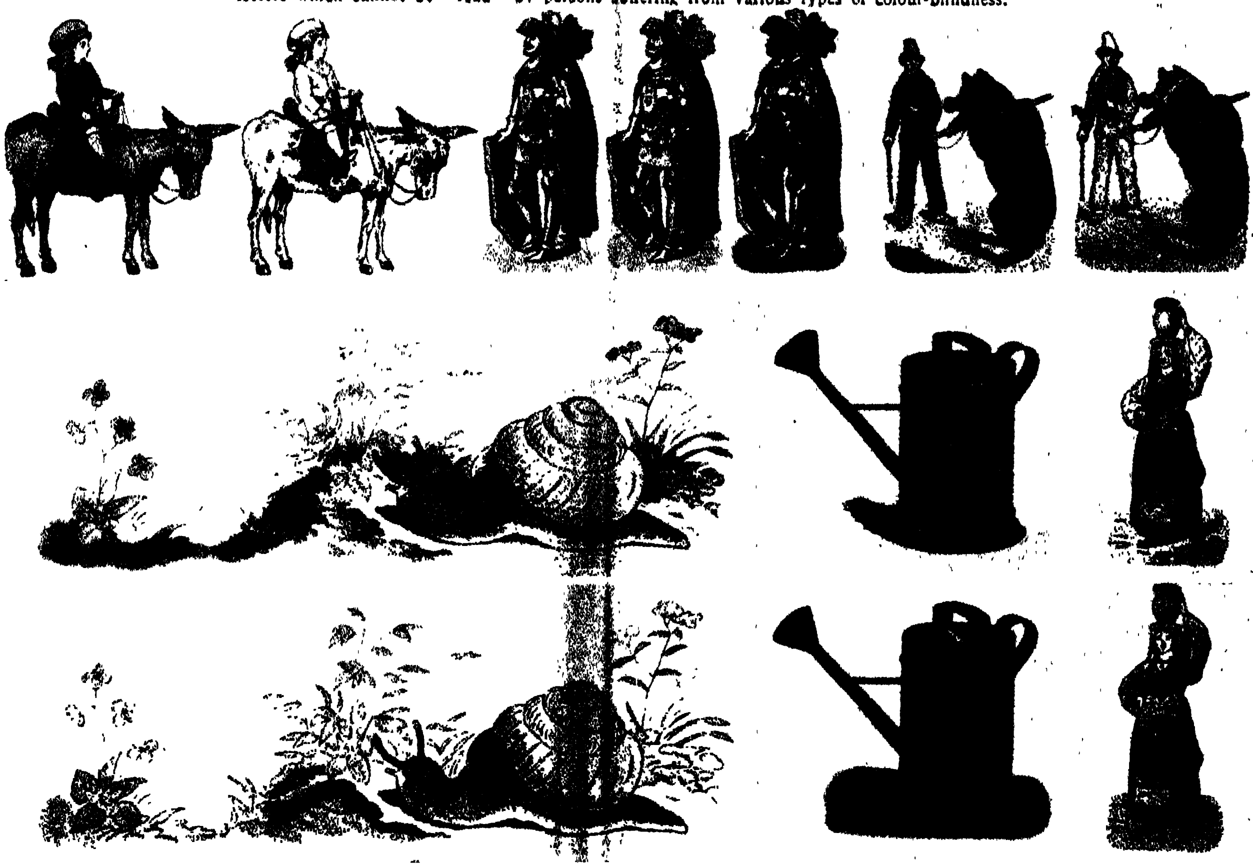


If two posts be driven into the ground a foot and a half apart, and with a loop of string 94½ feet long we draw an ellipse, as shown, this will represent the Earth's orbit in its exact shape. If, then, round the post nearer the north a circle is drawn ten and two-thirds inches in diameter, that will represent the Sun to scale. The Earth will be a circle one-tenth of an inch in diameter.

WHAT THE COLOUR-BLIND MAN CANNOT SEE

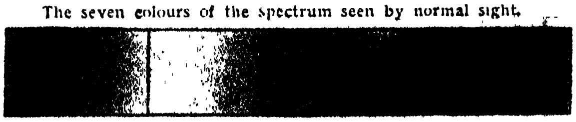


Above: selected specimens, greatly reduced, of cards used to test for colour-blindness. On them are outlined in spots of varying colours letters which cannot be "read" by persons suffering from various types of colour-blindness.

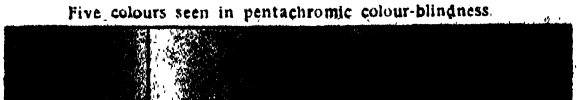


Above: drawings from a child's painting-book copied by colour-blind persons. The correct colouring is given first and then, on the right, or below, the colouring which appears natural to a colour-blind person.

The seven colours of the spectrum seen by normal sight.

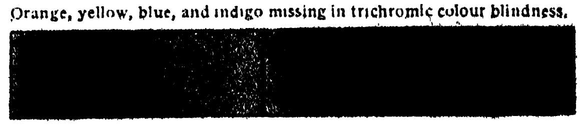


Five colours seen in pentachromic colour-blindness.

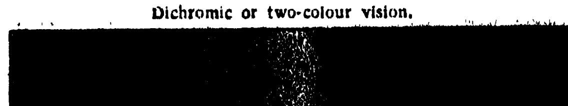


Orange, blue, and indigo missing in tetrachromic colour-blindness.

Orange, yellow, blue, and indigo missing in trichromic colour blindness.



Dichromic or two-colour vision.



Two-colour vision with a neutral band.

Test cards at top reproduced from "The Edridge-Green Card Test" by courtesy of G. Bell and Sons, Ltd. Remaining illustrations reproduced from original drawings by courtesy of Dr. Edridge-Green

WHY THE RIVERS WIND AND TURN

We do not have to know very much about rivers to realise that they vary a good deal in their character as well as in their size. Even in our own country there is much difference between a slow-flowing, winding river like the Beaulieu in Hampshire, shown on the next page, and a swift-flowing river like the Spey in Scotland, or between the Mississippi and the Colorado Rivers in the United States. The reasons for the differences are discussed in these pages

RIVERS are of many kinds. Where they run through more or less level plains they usually wind and turn as do the Thames and Forth, and many other rivers of Great Britain. But other rivers in rocky districts often follow more or less straight courses, and cut their beds deep down through the rock. The Colorado River in the United States flows in a chasm which is in parts a mile deep.

Rivers, like human beings, may almost be said to have life stories They are born, they have their childhood and youth, they pass into adolescence and maturity, and many of them reach old age. As with human beings, again, their appearance is very different at different ages.

A river is born, perhaps, as a spring emerging from the hillside, or it may be a gulley which has been shaped by the downrush of storm water after rain. Other gulleys carry water into it, and at first it runs straight. It cuts out for itself a channel in the soil, leaving steep banks on either side.

Its early stages, like those of many high-spirited, energetic boys, are generally turbulent. It is impetuous and wants to rush on ever more quickly. As it does so it digs its bed deeper and deeper, and if the surrounding area is dry and rainless, so that the banks do not get worn down, the river flows in a channel which is called a canyon with a precipice on either side.

How Bends are Cut

When the river is in flood the water is unable to spread sideways and so it rises rapidly on the canyon walls. At times the rise may be as much as fifty feet in a day or two. The river is therefore very swift-flowing, and sweeps away all obstacles in its path. But if there is a fall of rock, forming an obstacle on one bank, the current is thrown across to the other bank, and begins wearing it away, cutting both down and outward. In this way a bend in the river is eventually formed, and the current is then thrown back to the other bank and at once begins to cut a bend there

Thus the course of the river tends to wind, and whenever rain falls over the area, tributary streams are formed which run into the river and all have their part in levelling the country. Eventually, the river valley becomes more or less level, and as it does so the river tends to meander more and more. We see this in many of the rivers of England.

Sometimes where the river valley has become a level plain the bends become so exaggerated that at last the upper river joins the lower, matter is deposited and the bend or curve is cut off, forming what is known as an ox bow, or crescent-shaped lake. The name ox-bow is from the curved part of a yoke which fixes over an ox's neck.

How river in its youth carves a deep channel for itself with cliff-like banks on either side

A curious thing is that the exaggerated meandering of the river leading to the cutting off of the bends tends at last to straighten its course once more.

From all that has been said it will be seen that a river like the Colorado is really a river in its youth, while a river like the Mississippi is a river in its old age. The upper reaches of a river really indicate youth, while the lower reaches, where it winds, are a sign of old age.

Lord Avebury has pointed out that friction between the water and its channel checks speed. The friction is greater at the bottom and sides than in the centre and on the surface. Hence in a straight channel the velocity is greater in the middle than at the bottom or sides and, of course, it is greater in floods than at other times.

A rate of ten miles an hour is a rapid stream. The Thames runs at from two to three miles an hour, and the Tyne from one to two When the resistance of any object lying in the stream is less than the force of the water, it is moved on till it meets some obstacle or comes to a place where the slope of the bed reduces the speed.

Changing Speed into Work

When running water has taken up a quantity of earth and stones its energy is absorbed to some extent by the work of transport, and so its speed is diminished. In other words, the velocity has been converted into work.

A speed of three inches per second, says Lord Avebury, will move fine mud; six inches per second fine sand; eight inches sand as coarse as a pea; twelve inches will sweep along gravel as large as a bean; twenty-four inches will roll along rounded pebbles an inch in diameter, and a speed of three feet per second will sweep along angular stones the size of a hen's egg. Of course, the scouring power of the river increases with the speed.

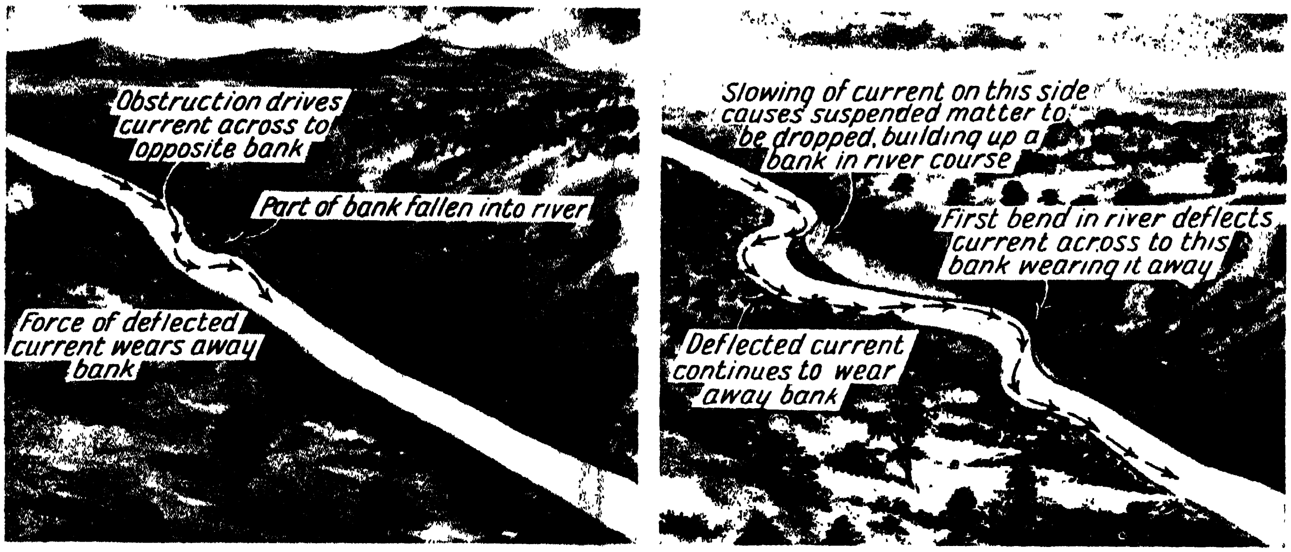
TWO DIFFERENT TYPES OF RIVER COURSES

This photograph, taken from the air, of the Beaulieu river in Hampshire shows the meandering type of river. With a slow current the least obstacle on one bank changes the direction of the flow and throws the water across towards the opposite bank which it begins to carve out, and so the curves and windings are formed till the river acquires the snake-like course shown here

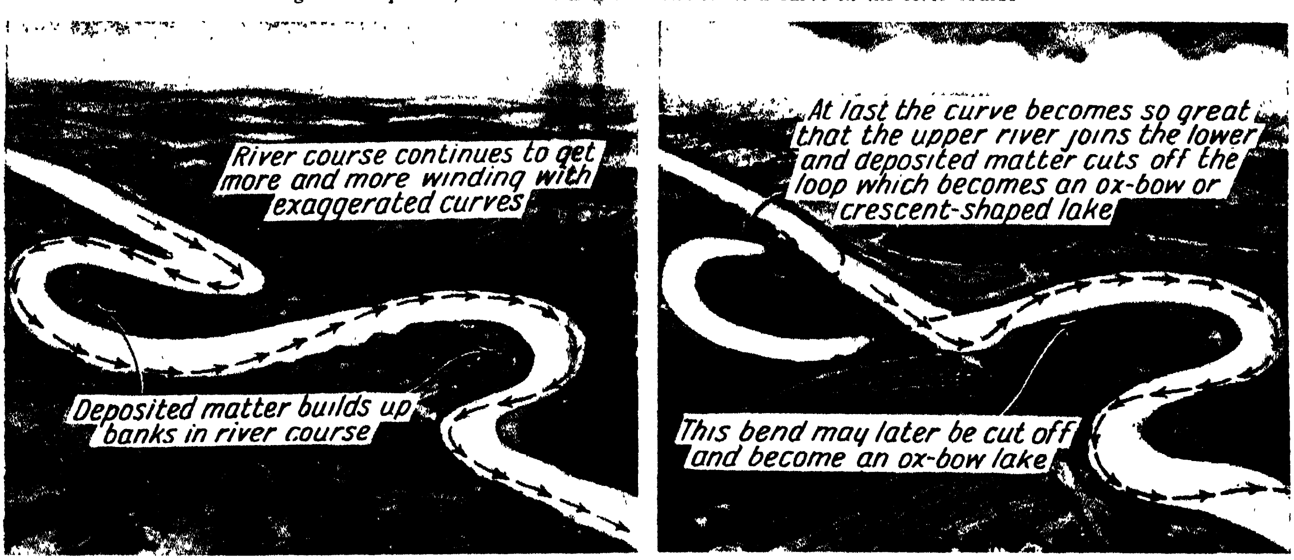
Here is the Colorado river, a very different type from the one shown above. Through the ages the swift-flowing river has been carving its bed out of the rock till now it runs through a great gorge which it has excavated, in some parts a mile deep. This form of river bed is due to the fact that the country is comparatively dry, and so there has been no rain with tributary streams to wear away the sides

THE STRANGE LIFE-STORY OF A RIVER

Rivers, like human beings, have their birth, youth, middle-age and old age. They are born from a spring or glacier or gully in which storm water collects, and they then flow towards lower levels, cutting out a bed in rock or soil. At first a river's bed is cut downward, but as time goes on and tributary rivers run into it, while rain and wind sweep over the banks, the bed becomes wider and the banks are worn more and more level. Here we see in section form the various stages of a river's history

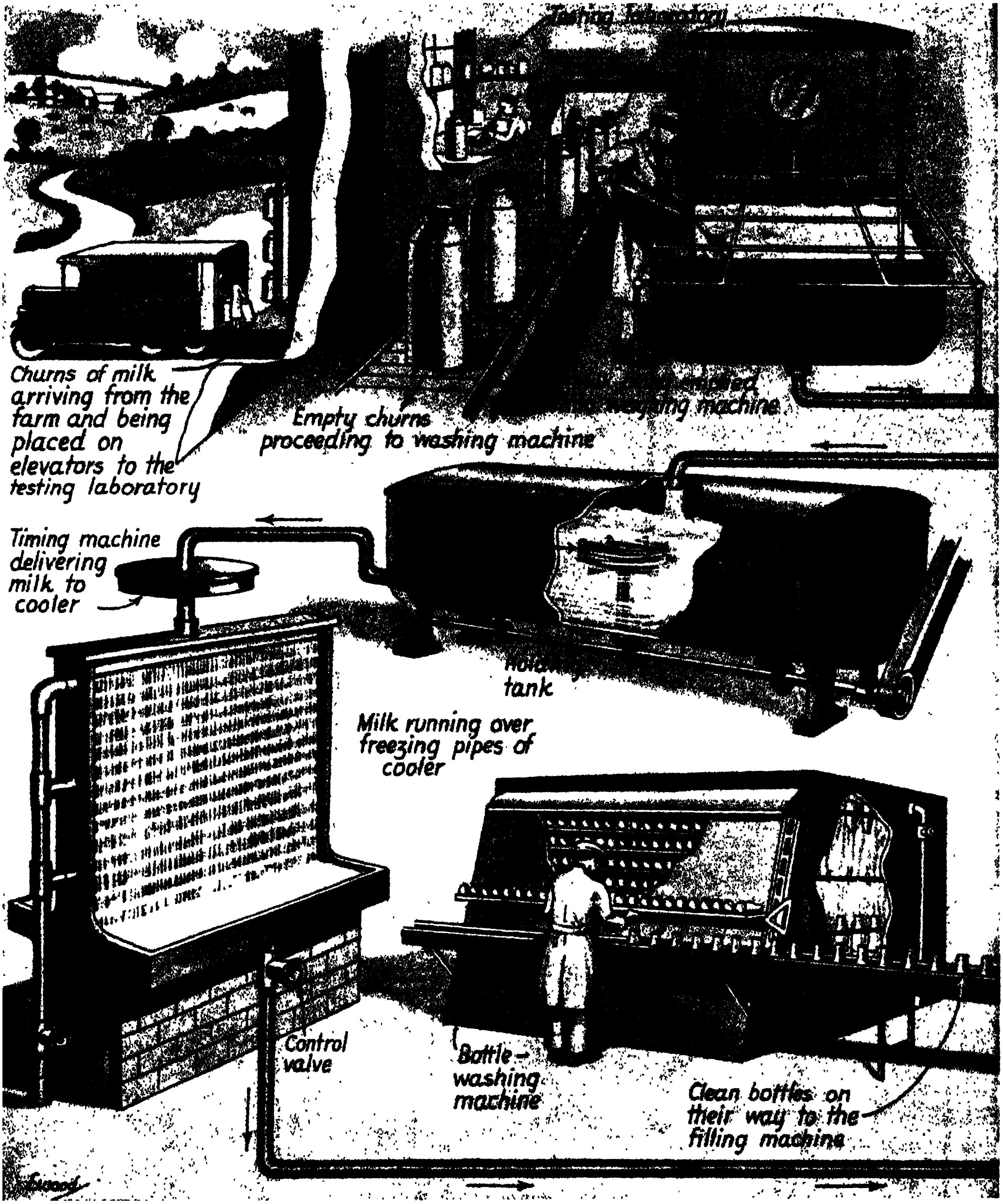


These pictures show how a river begins to meander and form bends as it runs away towards the sea. On the left is the river in its youth, but a fall of rock or soil on one bank has formed an obstruction throwing the current across to the other bank, which it begins cutting out. The slowing of the current on the bank where the fall occurred leads to a deposit of matter, and as we see in the right-hand picture, the result is the formation of a curve in the river course



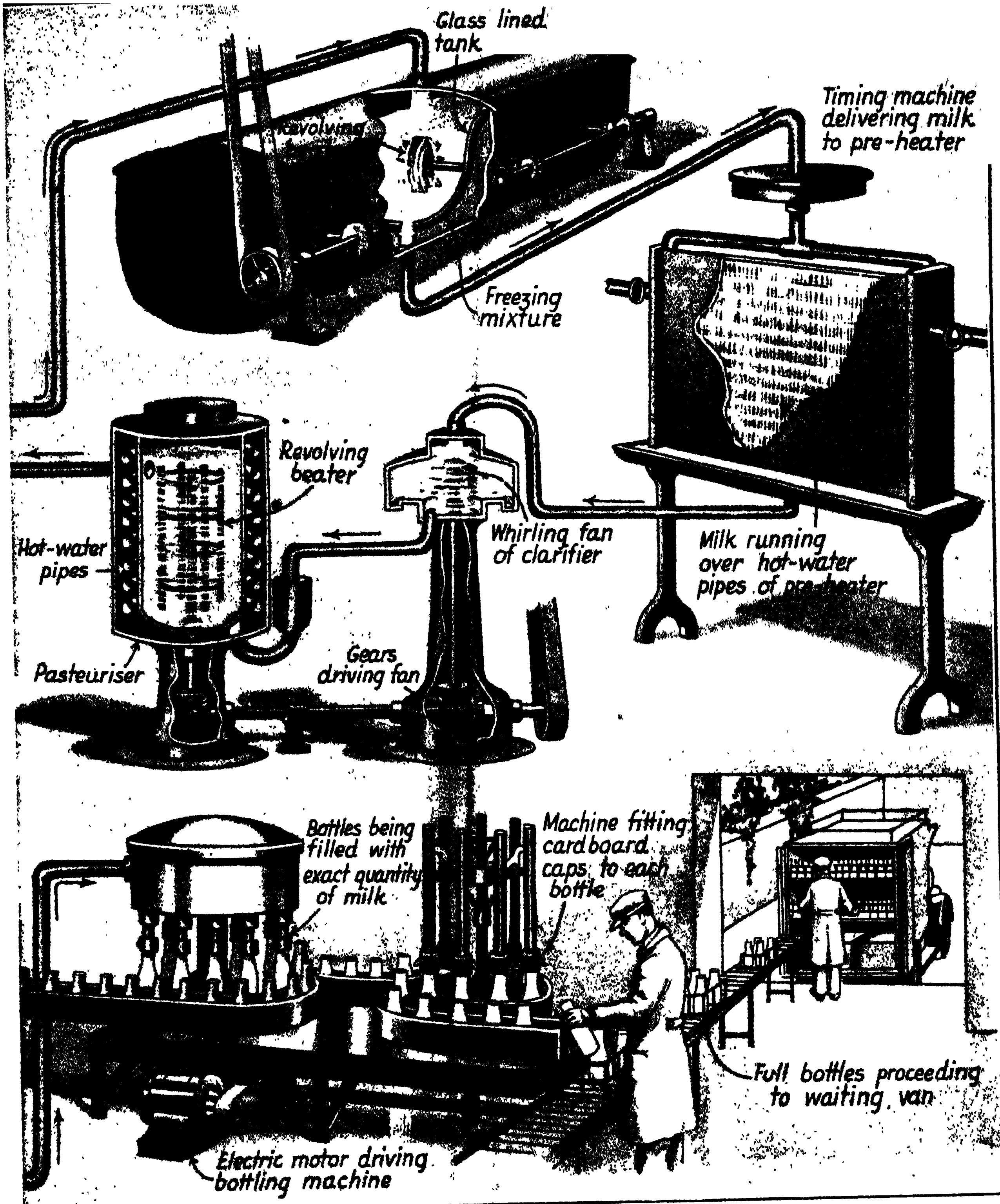
In these two pictures we see further progress in the meandering of a river. The bend becomes more and more marked till at last the upper and lower reaches of the river meet, and then the deposit of material cuts off the bend, which thus becomes what is known as an ox-bow, or crescent-shaped lake. Thus the increased meandering at last tends to straighten the river's course once more. Were it not for the fall of trees and earth from time to time a river would always run straight, because of the inertia of the quickly moving water. The more sluggish a river is the more likely it is to be turned aside by small obstructions, and once it is diverted from the straight course, as can be seen in these pictures, the curvature increases at an ever-growing rate. As the convex side of a meander or curve is scoured by the current and the earth is washed away, trees growing on the banks are undermined, and fall outward into the stream. Then when the next flood occurs these are carried down and often jam in narrow places along the channel, thereby causing fresh changes in the river. The word "meander" is from the Latin name of the river Maeander in Phrygia, which had many windings

HOW THE MILK FROM THE FARM IS TREATED



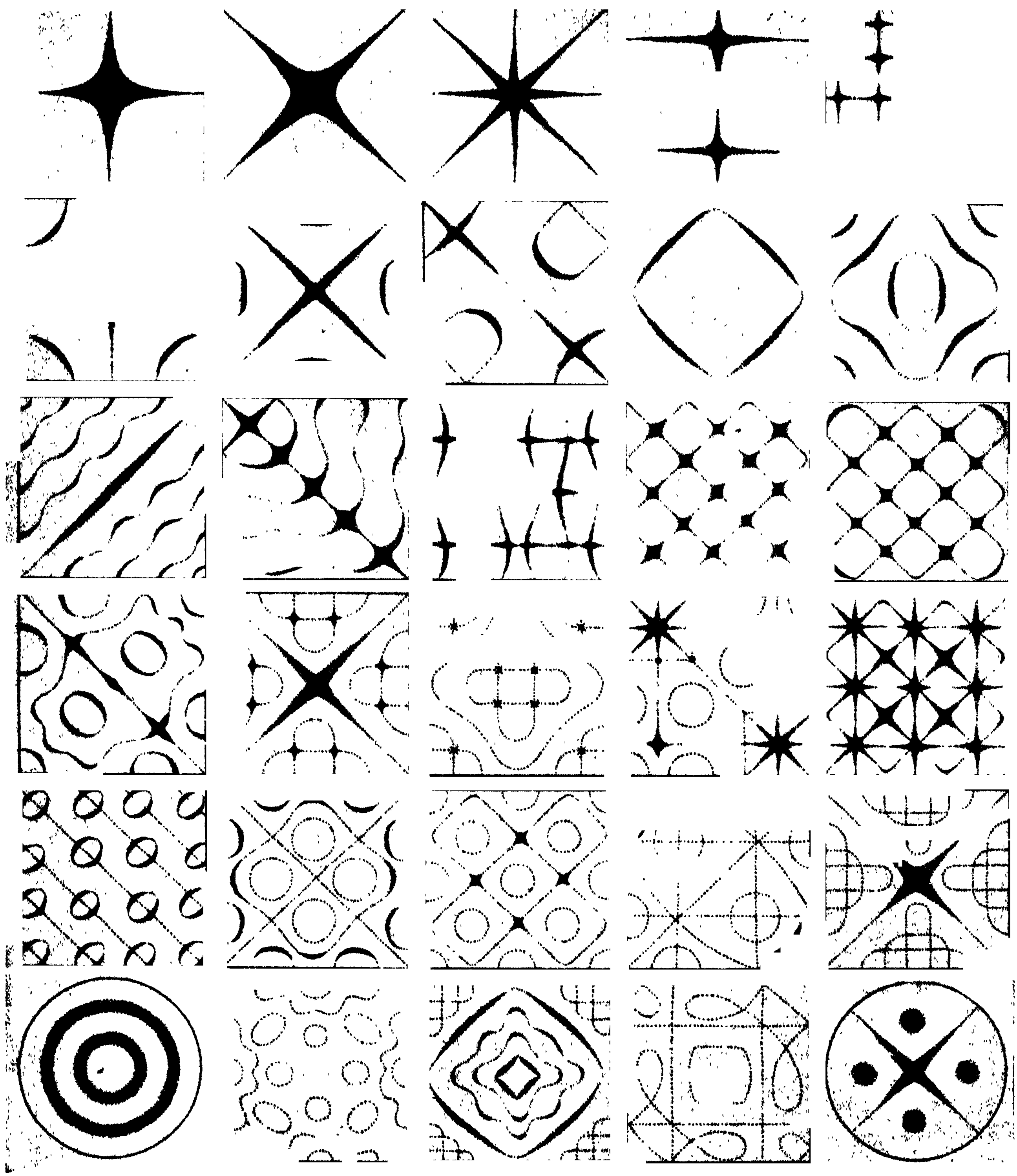
In this double-page picture we see how the milk which is gathered from the farms in many parts of the country is brought to the town, and after going through various processes, is packed in bottles and sealed ready for delivery to our homes. On arriving from the farm at the great modern dairy the churns are put on an automatic elevator and carried to the top of the building, where samples are taken and tested by bacteriologists in a laboratory. Everything being right, the milk is poured into a weighing machine and the empty churns pass on to a washing machine where they are cleansed and sterilized ready to be returned to the farm for the next consignment. From the weighing machine the milk flows to a storage or holder tank, which is glass lined, and which has a capacity of 1,000 gallons. Here a freezing mixture circulates between the glass milk holder and the sides of the tank which reduces the temperature to 40 degrees Fahrenheit. At the same time the milk is kept in motion by a beater which prevents the cream settling. The milk then goes to a timing machine electrically driven, which delivers it to an apparatus known as a pre-heater, at the rate of 2,000 gallons an hour. Here the milk flows over hot-water pipes which raise it to blood heat and make it flow very easily through a clarifier where

AT THE DAIRY AND BOTTLED FOR OUR USE



it is whirled round by a fan so that any solid matter is driven off by centrifugal force. The milk now passes to a pasteuriser where it is kept in motion by a revolving beater. Hot water pipes encircle the milk and raise the temperature to 145 degrees. This destroys any bacteria, but at the same time the nutritive properties of the milk are preserved. The milk next goes to a holding tank where it is again kept in motion for half an hour at a temperature of 145 degrees, and at the end of the period a valve opens and the milk flows through another timing machine to a cooler Here filtered air is blown through it and coils or tubes filled with freezing mixture reduce the temperature to 38 degrees Fahrenheit. The milk then passes to a filling machine where the sterilized bottles are filled automatically with the exact quantity and the bottles then travel to a capping machine which fits the cardboard caps upon them. They are then placed on a conveyor which carries them to the waiting van or to a cold store. In the bottle-washing machine the containers are thoroughly cleansed by steam and water at high pressure many times over, and are thoroughly sterilised. This cleansing of the returned bottles goes on at the rate of 8,400 an hour, and when clean they pass directly to the filling or bottling machine

BEAUTIFUL DESIGNS MADE BY A VIOLIN BOW



All the varied designs shown on this page were made by means of a violin bow on thin metal plates which had very fine sand sprinkled on them. Each plate was fixed at its centre to a stand, and the bow was drawn rapidly across one of the edges. In each case the plate was set vibrating, and by touching it in one or more places with the fingers while the bow was being drawn across, certain parts of the plate were kept at rest, while the other parts were vibrating. The parts at rest are called by men of science "nodes," and the fine grains sprinkled on the plate are moved by the vibrations towards the nodes or parts at rest. By touching the plates in different places and with a varying number of fingers while the bow is moving over the edge, a great variety of designs can be produced. It was a German scientist named Chladni who first discovered this behaviour of vibrating plates, and the patterns produced by the vibrations are called Chladni's figures, after their discoverer. The number of vibrations per second, and hence the particular patterns produced, depend upon the size and thickness of the plates on which the fine sand is spread. Similar figures may be produced on membranes stretched tightly on frames, if fine sand be strewn on them. In the case of the membranes, however, it is not necessary to draw the bow over them. They can be set vibrating by sounding a bell near them, the vibrations in the air thus caused vibrating the membrane

INTERESTING FACTS ABOUT VIBRATION

The music of stringed instruments is due to the vibration of the strings setting up wave motions in the air which strike our ear-drums, producing in the brain the sensation of ordered sound. In the same way the music of wind instruments is due to vibrations of the air enclosed in the instrument. The science of vibration is very interesting, and here we read many things about it, and learn some of the experiments which can be carried out in the home to illustrate the matter

MANY of our most pleasing musical instruments, such as the harp, the piano, the violin, and the guitar, owe their richness and fullness of tone to the vibration of strings.

There are four properties upon which these vibrations depend, namely, length, thickness, tension or the tightness with which the string is stretched, and density.

The rate of vibration is inversely proportional to the length of the string, which simply means that if one string is four times longer than another the rate of vibration will be a quarter. Then the rate of vibration is inversely proportional to the diameter or thickness of the string. Here again, if one string has a diameter four times that of another its rate of vibration is a quarter.

As to the tension or tightness of the string, the rate of vibration is directly proportional to the square root of the stretching weight. This means that if one string is stretched four times as tightly as another, its rate of vibration is only twice that of the other string. Finally, the rate of vibration is inversely proportional to the square root of the density, so that if one string is four times as dense or heavy as another its rate of vibration is only half that of the other string.

All this may seem rather mathematical and complicated, but the facts are mentioned and examples given for those who are interested in the matter. What, of course, is interesting to everybody is the cause of the beautiful sounds that the stringed instruments make either by plucking or by drawing a bow across the strings. The strings are set vibrating and the vibrations cause waves in the air which strike upon our ear-drums and send a message to our brain which is interpreted as sound.

But how is the great variety of sound produced from an instrument like the violin, which has only four strings? Well, the different tones are produced partly by having strings of different diameters and densities and partly by stopping or pressing a string firmly at some point in its length, say, at one half or one third or one quarter from the end as the bow is drawn across it.

By drawing a resined bow across the rim of a glass of water, as shown here, ripples can be set up in the water. As the bow is worked to and fro the ripples may become so violent as to break into spray

When the shorter segment of the string is agitated by having the bow drawn across it, it vibrates in two, three or four equal parts separated from each other by what are known as nodes. Now, the word node is from a Latin word meaning a knot, and a node, or nodal point as it is sometimes called, is a point in the length of a stretched string where, when the string is set vibrating, it is found to remain at rest.

If a wire be stretched tightly between two points and set vibrating while it is being touched at any point and then little pieces of cardboard shaped like an inverted V, thus Λ, be placed on the wire, it will be found that those placed on the parts that are vibrating will be thrown off, while those placed on the nodes will remain almost stationary. This experiment is a proof of the fact that there are nodes or parts of the wire at rest as well as parts that are vibrating.

A metal rod fixed at one end upright in a stand may be set vibrating as a whole or in segments like the string if the tip be plucked, first without touching any part of the length of the rod, and secondly by damping or touching the rod lightly at some point.

A tuning fork is really like an elastic rod which is free at both ends but is supported in the middle. It can be made of steel brass or gun-metal, but owing to the rate in the transmission of sound being different in different substances, a brass tuning rod is always made smaller than a steel one.

The velocity of sound in a steel tuning fork, which amounts to 5,237 metres per second, is about one and a half times as fast as the velocity in a similar brass fork. A tuning fork made of brass will be about a fifth lower in pitch than if the material were steel.

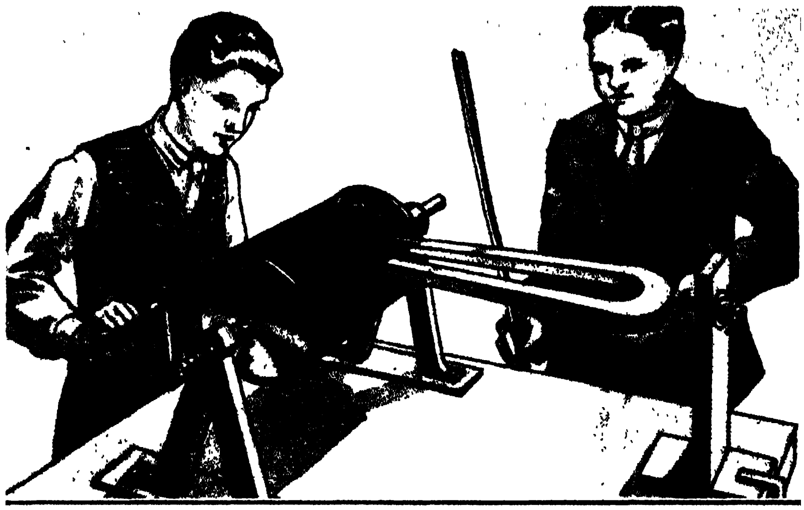
When a tuning fork is struck the vibrations are transmitted in the direction

How to form a design by drawing a bow across the edge of fixed plate on which fine powder has been sprinkled

of the stem which oscillates up and down at right angles to the prongs.

The science of vibrating strings and rods and tubes is of the greatest importance in the study of sound and those who take up this study carry out some very interesting experiments to illustrate the facts about vibrations and nodes.

The founder of the science of acoustics or sound was a German scientist named Ernst Chladni, who was born at Wittenberg in 1756, and died at Breslau in 1827. He made a very curious discovery. He was studying the question of vibrations and he found that when he took thin plates made of wood or glass or metal and fixed them solidly to a support at their centre he could make them vibrate in very curious ways.



In this experiment a sheet of smoked paper is wound round a drum, which is rotated. If a needle then be attached to one arm of a large tuning fork, and a resined bow be drawn across the fork, the vibrations set up will cause the needle to make a zigzag line on the smoked paper of the rotating drum

If he drew a bow across their edge and damped or touched them with one or more of his fingers at certain points, they vibrated in different ways and gave out very different sounds.

But Chladni was not content with the sounds. He wanted to learn more about the vibrations and the nodes, and so he strewed evenly over the surface of the plates some very fine sand. He was astonished to discover that when he drew the resined bow across the edge of the plate the fine sand on the surface was set in motion by the vibrations so that the grains arranged themselves in designs, and these designs varied according to the way in which he damped or touched the plates.

He used square, circular, triangular, hexagonal and octagonal plates, and he found that on all of these he could produce, merely by vibrating them with the bow, the most beautiful and complicated designs. As a plate vibrated the sand arranged itself in these varied forms. Some of the strange designs formed by the vibrating sand are illustrated on page 934. From their discoverer, the figures formed in this way are known as "Chladni's figures."

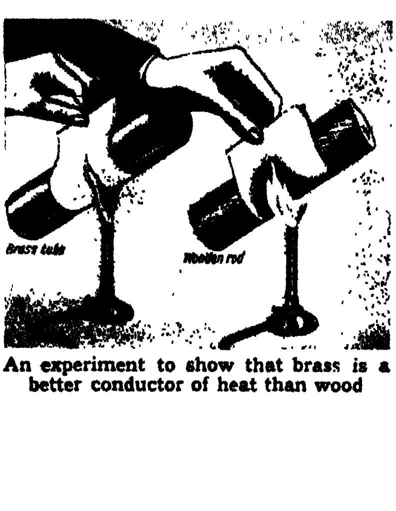
The experiments were continued by Faraday and other scientists, who got even better results by using instead of sand the still finer material known as lycopodium powder. In all these figures the grains seek the nodal points of rest in the plates and collect there, the lines being due to the grains endeavouring to travel to the nodes.

Any clever boy or girl can, with a little ingenuity, carry out similar and quite convincing experiments on a small scale in the home.

EXPERIMENTS ILLUSTRATING SOME FACTS ABOUT HEAT

There are many experiments which can be carried out at home to illustrate the science of heat. Different substances allow heat to travel through them at very different rates. Most metals are good conductors, that is, heat can travel through them very quickly. We find this when we put the poker in the fire. It is not very long before the handle gets hot.

Take a solid glass rod and an iron rod of about the same size and diameter—eight or nine inches long is a good length, and a quarter of an inch a suitable diameter. Attach near one end of these rods, at slight intervals, three or four ball-bearings, or small bullets, using sealing wax or candle-grease to attach them.



An experiment to show that brass is a better conductor of heat than wood

Now hold the rods side by side with the ends in a candle-flame. Before long the bullets will drop off the iron rod one by one, but it will be some time before they fall off the glass rod. The reason is that iron is a good conductor and glass is a poor conductor of heat. The heat soon reaches the grease or sealing-wax on the iron rod and melts it, allowing the bullets to drop, but it travels along glass slowly.

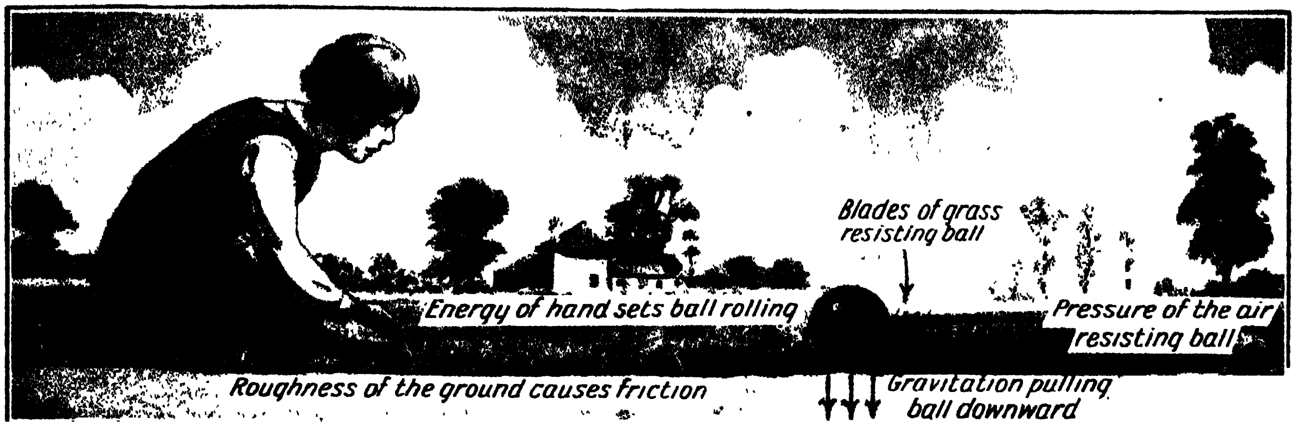
Another experiment illustrating the conduction of heat is shown in the first picture. Place a sheet of white paper round a brass tube and another round a wooden rod. Hold them in turn in the flame of a gas-burner or candle. The paper round the brass rod will not scorch readily, but that round the wood scorches very quickly. The reason is that the heat of the flame is conducted away rapidly by the brass tube, while wood is a bad conductor, and so the heat is not conducted away quickly, and scorches the paper.

An interesting experiment in connection with heat is to make a freezing mixture. We can do this by mixing powdered saltpetre and sal ammoniac and dissolving the mixture in water. If we put the thermometer in this mixture we shall find that it soon goes below freezing-point, and water in a tube immersed in the solution will become ice.

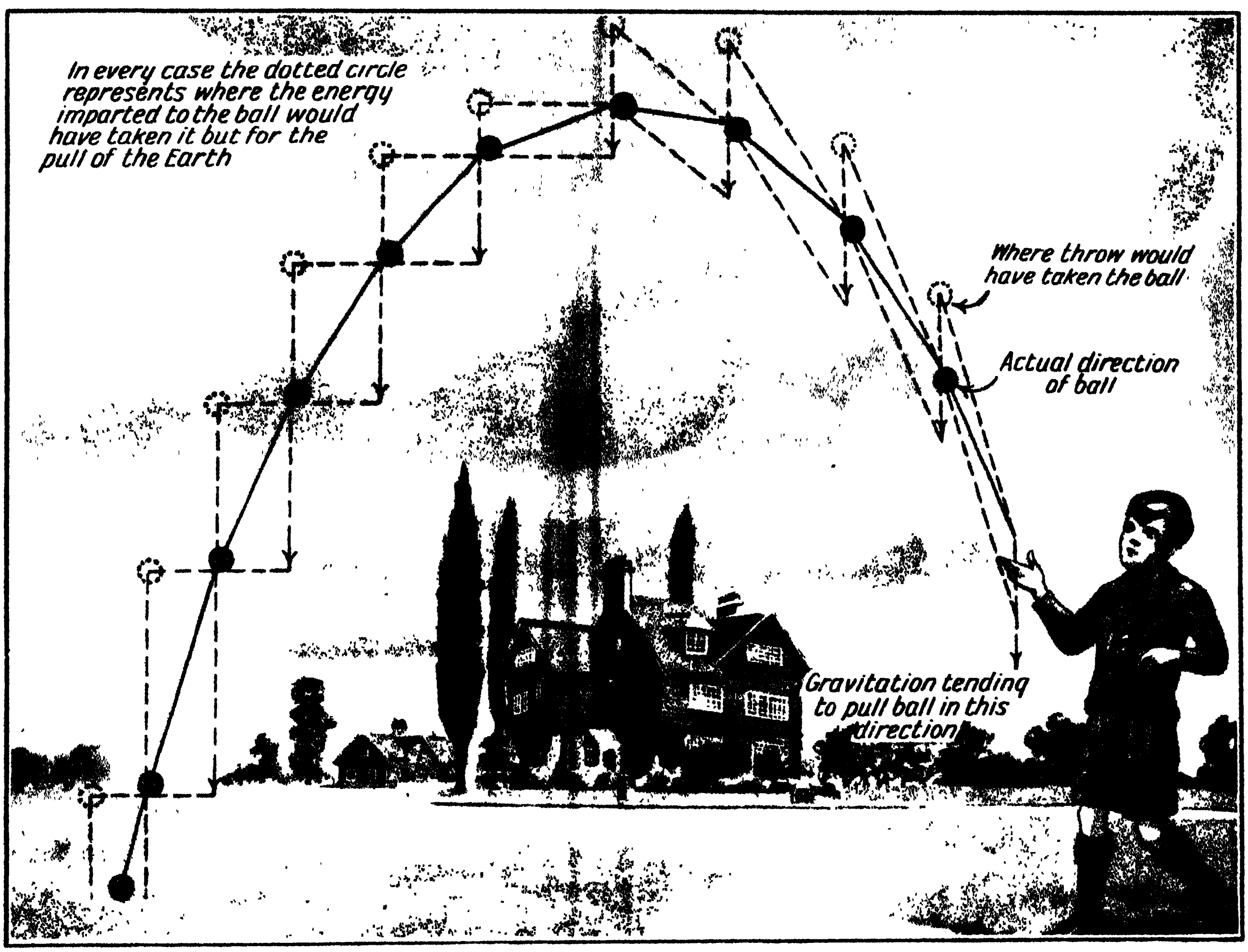
Salt and snow make a freezing mixture. If snow be placed in a pail and mixed with half its weight of powdered salt, it will be found that when a tin of cold water is stood in the mixture, the water will become ice. It is because snow and ice make a freezing mixture that the slush in the streets is so cold to the feet after salt has been thrown on the snow to melt it. The mixture of snow and salt needs a lower temperature to freeze it than the freezing point of water alone.

A freezing mixture made by dissolving saltpetre and sal ammoniac in water

SCIENCE LEARNT FROM A MOVING BALL

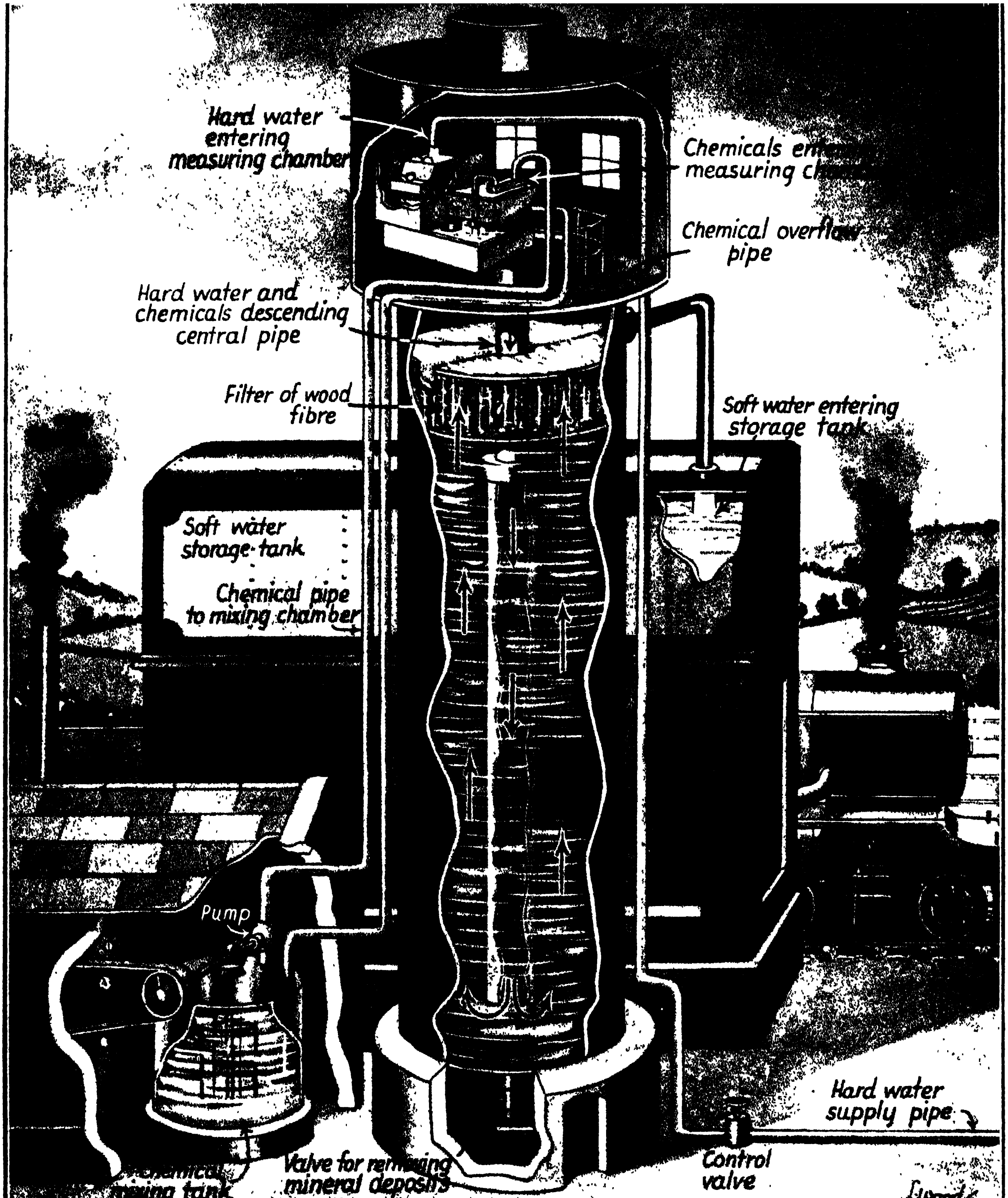


When a ball is set rolling along the ground it would go on for ever in a straight line were it not for various influences counteracting this motion. The air and blades of grass resist the ball, the roughness of the ground causes friction, and gravitation tends to pull it towards the Earth's centre All these opposing forces acting upon the ball as it rolls slow down its motion till at last it stops



A ball thrown into the air always describes a curve in its passage before it finally reaches the ground, and this curve is almost exactly a parabola—that is, the curve formed by cutting a cone through parallel with its side. We see what a parabola is on page 600. The path of the thrown ball is not quite a parabola because this is modified a little by the resistance of the air and by gravitation. When the ball is thrown up it gets a certain speed from the force of the throw, and in the first moment of time tends to go on in a straight line. But gravitation tends to pull it towards the Earth's centre. It goes, therefore, in neither direction but in a direction midway, which is found by drawing two straight lines to represent the force of the throw and the force of gravitation, forming a parallelogram, or four-sided figure on these lines, and then drawing a diagonal Tha represents the actual direction of the ball. From the point reached the ball tends to go on again the next moment in a straight line, but gravitation tends to pull it down, and so we can continue forming a series of parallelograms with their diagonals to represent the path of the ball at any moment. Of course, the ball in striking the particles of air gives up its energy and loses speed. It reaches a highest point and then gravitation begins to get more powerful than the diminished energy resulting from the throw. Eventually therefore the ball falls to Earth. Its path is along the diagonals of an infinite number of parallelograms For simplicity only a few are shown here greatly enlarged

HOW VERY HARD WATER IS MADE SOFT



In many districts the water is what we call "hard," that is, it has much mineral matter dissolved in it, such as the sulphates of lime and magnesium. In the kettle or boiler, it gives up some of this mineral matter, which is deposited on the side of the vessel. We generally call it "fur." Now fur is a great nuisance in boilers, and so where the water is hard factories generally have a water-softening plant, that is, an apparatus to precipitate the mineral matter before the water enters the boiler. Here we see the water-softening plant and how it works. In the bottom left-hand corner is a chemical mixing tank, in which carbonate of soda, or sometimes lime, is dissolved. The water containing this is then pumped to the top of a tower, where hard water from the mains enters a measuring chamber. When this chamber is full it rolls over and discharges the hard water into a tank. At the same time another measuring chamber filled with the water containing carbonate of soda likewise turns over, and the two waters are mixed. The sulphates are decomposed, and insoluble calcium carbonate and magnesium carbonate are formed, which are deposited on the tank bottom. The water, now soft, rises through a filter of wood fibre, and discharges itself over a ridge which leads to the outlet pipe, and so to the storage tank

THE ADVENTURES OF THE PRETENDER

Bonnie Prince Charlie, the Young Pretender, is one of the most romantic figures in British history. After the Stuarts had lost the throne this gallant young prince made a great bid to recover it. His charm and his bravery endeared him to all who came in contact with him, but his great enterprise was not successful, and he became a wanderer and a fugitive, as is described in these pages

PRINCE CHARLES EDWARD, known in history as the Young Pretender, must have been a rather lovable character in his youth. The name Bonnie Prince Charlie, given to him by his supporters, suggests that in both appearance and manner he was attractive. If the records speak truly, he had only to meet a Highland chieftain and the warrior was ready to lay down his own life and that of every follower in his clan for the sake of the Prince. This makes it all the sadder that his end was so miserable.

His early life, till the last hope of the Stuarts was lost in the defeat at Culloden, was one of bravery and thrilling adventure. His experiences were remarkably like those of his great-uncle King Charles II, except that they were harder and more prolonged, and he ran even greater risks of falling into the hands of his enemies.

German or Scot for the English Throne

To understand the story we must go back a little in history. When James II scuttled out of England he already had a son, James, who has become known as the Old Pretender. Sometimes he is called the Chevalier of St. George, the name by which he went when he wished to pass as a private individual.

Parliament, however, was determined that the Stuart Pretender should never mount the English throne, and it arranged that after the death of William III and James's two daughters, Mary and Anne, the crown should pass to the Princess Sophia, the Electress of Hanover, and to her heirs. Her claim to the throne was that she was the granddaughter of James I.

When in 1714 Queen Anne died, Sophia had already passed away, so her son, the Elector George, was invited to come over to England and become King, as George I.

But the Pretender, who was living in France, determined to make a bid for the throne, and gathering round himself some disgruntled nobles who had fled from England, he prepared to sail for Scotland. He had hoped to obtain the aid of French troops, but King Louis XIV, the bitter enemy of England, died just at this time, and the help was not forthcoming.

Meanwhile his friends in Scotland were busy and raised his standard at Braemar in 1715. Many Highland chiefs with their clansmen rallied to the standard, and an army of 10,000 was gathered under the command of the Earl of Mar, arms for these having arrived from France. Other chiefs, however, including the powerful Duke of Argyll, head of the great Campbell clan, sided with King George, so the Highlanders were divided.

Part of Mar's army marched into England, but there was no English support, and the Scotsmen when they reached Preston in Lancashire were compelled to surrender.

Bonnie Prince Charlie as a boy. From the painting by Nicolas Largillière

In Scotland, however, there was further indecisive fighting, and at this point the Pretender landed at Peterhead and began issuing proclamations under the name of King James VIII. But he had no personal magnetism to attract people, and his force soon melted away. On the 5th of February, 1716, just a month after landing, James took ship again and fled to France. He escaped with his life, but many of his unfortunate followers were executed, though the Government did not act with very great severity. This invasion is known in history as "The '15," which is simply a shortened form of "The Rebellion of 1715."

It is rather interesting to remember that while in this campaign of 1715 the Highlanders fought bravely and fiercely against the English, exactly a century later, in 1815, they fought with equal gallantry with the English against the French at Waterloo.

After James's flight the Stuart cause was lost for the time being. It was not till the next reign, that of George II, that another serious attempt was made by the Stuarts to regain the throne, and this time it was not the Old Pretender, but Bonnie Prince Charlie, the Young Pretender, who went to Scotland and staked his fortune on the chance of victory.

The Stuart Cause Revived

France had declared war against England in 1744, and the Young Pretender, known among his friends as the Prince of Wales, was sent with a French fleet to invade England. But the fleet was driven back to France by the combined efforts of the English fleet and a fierce storm.

The Young Pretender, however, was determined to attempt the invasion of England, so as to win the crown for his father, and although he could get no further French help, he said he would go to Scotland and raise his standard even if he took only a single footman with him. His supporters thought such a scheme a mad one, but Charles was determined. Pawning his jewels and borrowing a large sum of money, he hired two ships, and on July 13th, 1745, set sail for the Scottish coast.

But on the way he fell in with an English man-of-war, which attacked one of his ships. After a battle of six hours, both vessels were badly battered, and the French ship, which had on board a supply of arms and ammunition, had to return to Brest, while Charles, in the other ship, went on and landed on an island in the Hebrides on August 2nd. His supporters there urged him to return to France at once, but Charles would hear nothing of this.

"I am come home," he said, "and I will not return to France, for I am persuaded that my faithful Highlanders will stand by me."

News went round that the Prince had arrived and, with one or two exceptions, the clans flocked to his aid.

He raised his standard at Glenfinnan on August 19th and at once began to march south.

King George's supporters at once became greatly alarmed, and a price of £30,000 was put upon the Prince's head. The Government gathered a body of troops, but Charles eluded them and reached Perth, where he stopped for a week to drill his forces. Then he marched to Edinburgh, where the people received him with great enthusiasm, although the castle was held for King George.

London Begins to Tremble

Sir John Cope, commanding the Government troops, was badly defeated at Prestonpans, and now the supporters of King George began to lose heart. Their most capable officer, Marshal Wade, declared that Scotland was lost and that England would soon fall.

Even in London the alarm was great, and Horace Walpole, the son of the Prime Minister, wrote to a friend that he expected to have to leave his home in London for some wretched attic on the Continent, where he would probably have to give lessons in Latin for a living

Marshal Wade was told to march north with a large force, the militia were called out, and the Duke of Cumberland, King George's son, was recalled frantically from Flanders with three battalions of the Guards and seven regiments of infantry to meet the Stuart menace in the North.

Meanwhile Prince Charles marched farther and farther south; determined to reach London as soon as possible, before the fear his presence had inspired had time to abate. He captured Carlisle, gave the slip to Marshal Wade, and also to the Duke of Cumberland, who had landed and travelled north with his troops, and at last entered Derby.

London was staggered at the news. The tradesmen were afraid to open their shops, all business was suspended, and there was a run on the bank. Urgent messages were sent to the Duke of Cumberland to return at once for the defence of the capital.

But, strangely enough, at this very time of apparent success there were dissensions in the Young Pretender's army. The Prince wanted to press on to London, but Lord George Murray, his commander, and other officers, realising that they were gaining no support in England at all, declared that their cause was hopeless, and that they must retreat immediately. Charles protested, but was overridden, and as soon as daylight dawned on December 6th the Highland army turned round and began its retreat to the North.

The Rout of Culloden Moor

The clansmen marched very rapidly, and again outwitted both the Duke of Cumberland and Marshal Wade. The Duke followed them and at Culloden Moor, on April 14th, 1746, inflicted a crushing defeat upon them The Highlanders were fierce and gallant fighters, but the English guns had raked their ranks, and after the battle they were found lying in layers three and four deep.

The horror of the slaughter almost overpowered Charles, and he left the fatal field with a few supporters. At Ruthven a feeble attempt was made to rally the scattered Highlanders, but it failed, and Charles fled, to begin those months of wanderings as a hunted fugitive which form one of the most thrilling stories in British history.

Charles was led by a poor Highlander, Edward Burke, to the house of the aged Lord Lovat, where many cooks were busy preparing a great feast in honour of the victory which was expected.

The Long Flight Begins

The noise and excitement were intense, when Charles, with a few attendants, entered the house and informed the aged chief of the disaster. It meant ruin to Lord Lovat and his family, and one account says that the chief ran about in distraction crying "Chop off my head, chop off my head!" Another account says that when the Prince declared his intention of abandoning the enterprise, the old chieftain said to him fiercely, "Remember your great ancestor, Robert Bruce, who lost eleven battles and won Scotland by the twelfth."

The house-party had to break up hurriedly, and Charles and his attendants rode all night to Invergarry, the seat of one of his supporters, Macdonell. The house was deserted, and without furniture or provisions. The Prince and his party were so tired with their long night ride of forty miles that they stretched themselves upon the floor in their clothes and slept till midday.

Meanwhile their Highland guide had caught two salmon in the River Garry, and these, together with water from the river, formed their only meal.

Charles's escort now left him, except for two men and the guide Burke, whose

Prince Charles Edward entering Edinburgh after his landing in Scotland. From the painting by Thomas Duncan

clothes the Prince donned for the sake of disguise.

The small party set out at two o'clock in the afternoon for Loch Arkaig, where they arrived at nine at night, and went to the house of one Donald Cameron Charles was so worn out that he actually fell asleep while Burke was unbuttoning his leggings.

The next morning, which was Friday, April 18th, the Prince continued westward and came to a farmhouse, where he was well entertained and had the first decent meal for several days. He waited for a great part of the following day to hear intelligence of his friends, but this not arriving, and fearing that he might be discovered, he moved on.

He and his friends were now in a part of the country where there were no roads, and so were obliged to abandon their horses and travel on foot. By evening they had reached a place called Oban near the head of Loch Morar, and took shelter in a wretched hovel used for shearing sheep near the corner of a wood.

The next day was Sunday, April 20th, and Charles and his three attendants, with great pain and difficulty, crossed a range of lofty hills which were penetrated by many arms of the sea and made travelling difficult.

Danger on the Sea

They came to a village, where they were joined by several fugitives, including Mr. Aeneas Macdonald, who reported that the western seas were being patrolled by English vessels, so that escape in that direction was, for the time being, impossible.

Charles thought the best thing would be to trust himself among the Macleods in the Isle of Skye, but one of his attendants, Clanranald, suggested that it would be better for him to remain where he was, and said that a number of cots or huts could be fitted up among the hills, in which he could hide until it was safe to make a trip to the Isles, and look for a ship to carry him to France.

Mr. Macdonald sent a message to a faithful old servant, Donald Macleod of Skye, desiring him to come to act as guide to the Prince. Donald set out at once, and while passing through a forest he met a stranger walking by himself.

"Are you Donald Macleod?" asked the stranger.

"I am, please your highness, at your service," replied Donald, who had recognised the Prince quite easily through his disguise.

"Then," said the Prince, "you see, Donald, I am in distress. I put myself in your care. I hear you are an honest man and fit to be trusted."

Donald, with tears streaming down his cheeks, promised to serve the Prince. Charles thereupon asked Donald to carry letters to Sir Alexander Macdonald and the Laird of Macleod, asking their protection, but the old man positively refused, revealing the fact that so far from being inclined towards the Prince, they were at this moment out with their men searching for him to capture him.

Charles therefore decided to make for the Isles, and on the evening of the 24th, with ten people, set sail in an open eight-oared boat from Lochnanuagh, the bay in which he had first landed. Donald Macleod acted as pilot.

The Young Pretender with two of his friends. From the painting by John Pettie

The boat was hardly out to sea when a fierce storm arose and the whole party was in the most imminent danger. Donald said that it was the fiercest storm he had ever seen on that wild sea. The rain poured down in torrents, and it was too dark to see anything at all. None of the crew knew where they were, and the party was afraid that the boat would either founder or be driven upon the Isle of Skye where the militia were searching for the Prince.

After what seemed an interminable night, daylight at last dawned, and showed the travellers that they were off the coast of Benbecula, the storm having driven the boat more than sixty miles in nine or ten hours.

They landed on the island, drew their boat up on the shore, and prepared a simple breakfast consisting of meal and the flesh of a cow which they had seized and killed.

The storm continuing, Charles prepared to stay on this island for a time, and as one historian has said, "A cowhouse destitute of a door was the palace; his couch of state was formed of filthy straw and a sailcloth, and the regal banquet composed of oatmeal and boiled flesh was served up in the homely pot in which it had been prepared."

On April 29th he and his party set sail for Stornoway in the island of Lewis, where Donald Macleod hoped to find a vessel which would convey the Prince to France, but again a storm came on and the little craft was driven to the small island of Glass, forty miles north of Benbecula, and the same distance from Stornoway.

The Prince and his attendants disembarked just before daybreak, and finding that the people were hostile to the Stuart cause, he and his party assumed the character of merchantmen who had been shipwrecked on a voyage to Orkney.

Seeking a Ship

Donald Macleod set out to see if a ship for France was available, and on May 3rd he sent word to the Prince that he had succeeded, and urged Charles to sail for Stornoway immediately. Again the Prince started for this port, and again the wind blew him out of his course. He had to land in Loch Shetfort, twenty miles from Stornoway, and then walk on foot over a pathless moor which was very wet. The guide was ignorant of the way, and not until noon on the 5th did the Prince approach Stornoway.

He stopped about half a mile from the town and sent his guide on to Donald Macleod imploring him to bring out some refreshment. Donald came, bringing food, and then led the party to the house of Mrs. Mackenzie, where the Prince had some much-needed sleep.

Donald went back to Stornoway to make arrangements, but was staggered to find that his servant, having become tipsy, had let it be known that the vessel about to set out was to carry the Prince. He had been boasting that if there was any nonsense about detaining it the Prince would be able to seize the vessel by force.

Naturally the people became alarmed and hostile, but Donald tried to appease their fears, and partly by appealing to their pity and partly by threats, he got them to agree to the departure of the vessel. Nobody, however, would act as pilot.

This state of things at Stornoway alarmed the Prince's party, and it was considered best to sail away next morning by the boat The Prince wanted to go to Orkney, but the crew, now reduced to two, refused to take so long a voyage. It was then decided to steer southward.

Scarcely had the boat started when four large ships appeared in the distance, and the Prince put into a small islet on which a few fishermen were temporarily at work These believing that the Prince's party was a press-gang, fled, leaving large quantities of fish on the shore. The food was welcome to the voyagers, who made a hearty meal and then took refuge in a hovel with a leaky roof. After covering this with a sailcloth they lay down upon the floor, taking it in turns to keep watch

The party stayed for four days on this little island, and then on May 10th started off in their boat once more, calling at Glass on the way. They were about to land when four men came up and attempted to seize the boat. They therefore pushed off from the shore and rowed all night, although they were now very faint for lack of food.

At daybreak they hoisted a sail, but having no fresh water they spent a miserable day, eating nothing but meal stirred into sea water. Charles declared that if ever he mounted the throne, he should not fail to remember those who dined with him that day.

Suddenly the boat found itself near an English man-of-war, which at once gave chase. The Prince called on the men to row with their utmost speed, saying, "If we escape this danger, you shall have a handsome reward; if not, I'll be sunk rather than be taken."

The chase went on for nearly ten miles, and then the wind dropped and the warship was becalmed

Charles had had so many escapes that he declared exultingly to his companions that he was not designed to die by either weapon or water.

The only food available consisted of crabs which Charles and his friends caught among the rock pools. Charles himself carried the bucket to a hut two miles inland. The door was so low that the fugitives had to crawl in on their hands and knees. As the Prince intended to remain there for some time, he ordered Edward Burke to lower the threshold so that the party could go in without crawling.

Soon afterwards, Clanranald came to the Prince's hut bringing with him provisions, wine, shoes and stockings. A historian has said that he found the Prince reclining in a hovel little larger than an English pigsty, and perhaps more filthy, his face haggard with disease, hunger and exposure to the weather, and his shirt as dingy as a dish-clout. Clanranald obtained six good shirts for the Prince, who, it was decided, should remove to a more secure hiding-place near the centre of South Uist.

Before moving, Charles sent Donald Macleod to the mainland to his supporters to discover the state of affairs there. He received letters informing him of the utter ruin of his cause, and although the Prince had asked for a supply of cash, none was forthcoming. Donald was eighteen days upon this mission.

The Prince had by this time removed to South Uist, and was in a rather better hut, and when he slept he had two cowhides stretched on four sticks as an awning to cover him. Charles spent some time shooting wild fowl, and he also went out fishing.

Bonnie Prince Charlie hiding after his defeat by the English forces under the Duke of Cumberland at Culloden

It must be realised that all this time, while the Prince was moving about among poor people, who were fully aware of his identity, he had a price of £30,000 set upon his head. The alternative for concealing the Prince was imprisonment and probably death, yet not once did any of the people entertain for a moment the idea of betraying the Prince.

Charles spent several weeks in South Uist. One day, we are told, he shot a deer, and as some slices of meat from this beast were being cooked, a poor, starved boy came up and, seeing the dish, thrust his hand into it. The man acting as cook reproved the boy and pushed him away, when Charles interfered, saying, "Ned, you don't remember the Scriptures, which enjoin

us to feed the hungry and clothe the naked. You ought rather to give him meat than a stripe."

Charles then ordered that the boy should be supplied with clothes, and paid for them himself, saying, "I cannot see anyone perish for lack of food or raiment, having it in my power to preserve him."

This boy must have been an ungrateful little wretch, for after being fed and clothed, and having guessed that the Prince was a person of quality, he went off and told a force of 1,500 Campbells and other hostile clansmen where the Prince was. Fortunately the boy's tale was not believed, and so Charles escaped.

We are told of Charles at this time that his dress was a tartan short-coat and vest, his night-cap "all patched with soot-drops, his shirt, hands and face patched with the same; a short kilt, tartan hose and Highland brogues, his upper coat being English cloth."

The militia were now becoming very active, and Charles realised that his position in South Uist was one of great danger. He must shift his quarters, so entering the boat once more he went first to one island and then to another, sometimes having to flee from warships that were searching for him.

Charles was now much hunted and harassed. He could scarcely rest for a few hours before news of the militia would be brought and he would have to hasten off to another hiding-place. Never has man been more harassed than was the young Stuart Prince.

Now comes the most romantic part of the story. A young lady, Flora Macdonald, who lived in Uist, was asked to aid the Prince. The story of how this girl, now famous in history, first met the Young Pretender is told by one of the Prince's attendants.

"At midnight," he says, "we came to a hut where by good fortune we met with Miss Flora Macdonald, whom I formerly knew. I quitted the Prince at some distance from the hut, and went with a design to inform myself if the Independent Companies were to pass that way next day, as we had been informed.

"The young lady answered me 'Not,' and said that they were not to pass till the day after. Then I told her I had brought a friend to see her, and she, with some emotion, asked me if it was the Prince I answered her it was, and instantly brought her in.

"We then consulted on the imminent danger the Prince was in, and could think of no more proper and safe expedient than to propose to Miss Flora to convey him to the Isle of Skye, where her mother lived. This seemed the more feasible, as the young lady's stepfather, being captain of an Independent Company, would accord her a pass for herself and a servant, to go to visit her mother.

"The Prince assented, and immediately proposed it to the young lady, to which she answered with the greatest respect and loyalty, but declined it, saying Sir Alexander Macdonald was too much her friend for her to be the instrument of his ruin. I endeavoured to obviate this by assuring her Sir Alexander was not in the country, and that she could, with the greatest facility, convey the Prince to her mother's, as she lived close by the waterside

"I then demonstrated to her the honour and immortality that would redound to her by such a glorious action; and she at length acquiesced, after the Prince had told her the sense he would always retain of so conspicuous a service. She promised to acquaint us next day, when things were ripe for execution, and we parted for the mountains of Coridale."

Flora Macdonald, after herself being arrested under a misapprehension, obtained the necessary passport for herself, her servant, and a female named Betty Burke, under which character the Prince was to be concealed. Flora and a friend, Lady Clanranald, obtained the necessary disguise and went to the hut where the Prince was hiding.

On entering it they found Charles roasting the heart and liver of a sheep on a wooden spit. The party sat down to dinner, and then arrangements were made to carry out the plan.

On the morning of Saturday, June 28th, Flora Macdonald told Charles to dress himself in the disguise, which consisted of "a flowered linen gown, a light-coloured quilted petticoat, a white apron and a mantle of dun camlet, made after the Irish fashion with a hood."

The party set off for the beach, one of their number, it is interesting to note, being Neil Macdonald, who later became the father of Napoleon's Marshal Macdonald, the Duke of Taranto

Arrived at the beach, very wet and tired, the party lighted a fire on the rock so as to keep warm till night. Suddenly they spied four wherries full of armed men apparently making towards the shore. They at once extinguished their fire and hid themselves. The wherries, however, sailed on towards the south without stopping, although they passed within gunshot of the hidden fugitives.


The party set off for the beach, one of the Prince's party being Neil Macdonald, who later became the father of Napoleon's Marshal Macdonald

At eight o'clock that evening the Prince's party left Benbecula and set out for Skye. Soon after they had started, a storm blew up and the sea began to rage, and when day dawned the boat was out of sight of land, and no one knew what its position was.

Sailing on, however, the party soon discerned the mountains and headlands of Skye, and going near the shore were preparing to land when they saw a body of militia. These men had a boat but no oars, and the men in Miss Macdonald's boat at once began to pull in the opposite direction.

The soldiers called on them to stop, or they would fire, but it was felt that they must escape at all risks. The soldiers began to fire, but fortunately hit no one. Charles implored Miss Macdonald to lie down at the bottom of the boat so as to avoid bullets, but she refused unless he also would take the same precaution, and after some argument the two lay at the bottom of the boat while the rowers pulled out of danger.

To tell the whole of the Prince's adventure would require a book. Flora Macdonald with her supposed Irish maid arrived at the seat of Sir Alexander Macdonald at Mugstat, where it was arranged that Charles should remain for a few hours on a hill near the house, while Flora dined with Lady Macdonald. At Lady Macdonald's table dined also an officer of the Duke of Cumberland's army, who was stationed there with a party of soldiers to watch for the Prince, should he land in Skye. After Charles's escape this lady often laughed at the officer in question for her skill in deceiving him.

Miss Macdonald accompanied by some male and female servants of Lady Macdonald, set out and soon came up with the Prince, who was with a laird named Macdonald, also called Kingsburgh after his home Kingsburgh House, to which it was arranged the Prince should be conducted.

An Impudent Jade

Charles was poor at disguise, and one of Lady Macdonald's servants, a girl, observing him, exclaimed that she had never seen such a tall, impudent-looking woman in her life. "See," she continued, addressing Flora, "what long strides the jade takes. I dare say she is an Irish woman, or else a man in woman's clothes."

As they travelled they met numbers of country people returning from church, who all stood and stared at the uncommon height and awkwardness of the supposed female. In crossing a stream Charles, in order that his clothes might not get wet, held up the skirts a good deal higher than ladies of those days were accustomed to do. Kingsburgh pointed out that such indelicate behaviour would excite suspicions among the people, so when crossing the next stream Charles allowed his skirts to hang down too low, and they floated upon the water. Kingsburgh again had to point out that this practice would be as likely as the other to attract observation. "Your enemies," remarked Kingsburgh, "call you a pretender, but if you be I can tell you you are the worst at your trade I ever saw."

That night the Prince slept at Kingsburgh's house, more soundly and for a longer period than he had been able to do for many nights past. He was fitted out with a new pair of shoes, his old ones having been worn out. "These," observed the donor, "I will keep until you are safely settled at St. James's."

Kingsburgh kept them as long as he lived, and after his death they were bought by a zealous Jacobite for twenty guineas. The sheets in which Charles had slept were also folded up after his departure and never allowed to be washed again.

At Kingsburgh House Charles nearly betrayed himself, for a servant girl who was sent down into the hall to get something for the mistress rushed back declaring with great alarm that she could not go into the hall for fear of the tall woman who was walking backwards and forwards through it in a manner perfectly frightful.

Charles implored Flora Macdonald to lie down at the bottom of the boat so as to avoid the bullets

The party now travelled on towards Portree, and Charles, fearing detection because of his awkwardness, changed from petticoats into a tartan coat and waistcoat, a kilt, a plaid and a wig and bonnet.

At Portree Miss Macdonald left Charles, but his wanderings were far from over. No news could be heard of a ship sailing for France, and he lived for a time in a cowhouse.

Then, with Malcolm Macleod as a guide, the Prince wandered over the mountains to get into the country of the Laird of Mackinnon. Charles passed as the servant of Malcolm Macleod, and took the name of Lewie Caw.

Eventually they came to Mackinnon's house, and then it was determined that Charles should be taken to the mainland, while Malcolm remained in Skye for fear he should be missed.

Charles reached the mainland after another rough voyage, and landed at four in the morning at a place called Little Mallack, on the south side of Loch Nevis. Here his risks became greater than ever, but he found friends, and by constantly moving about managed to dodge the troops who were searching for him.

At last he got into a place where he was completely surrounded. There was a chain of sentries round a large area, and at night fires were kept burning between them. The fires were placed at brief intervals, and every quarter of an hour a patrolling party passed to see that the sentinels were on the alert

Escape at Last

It seemed impossible that the Prince could ever break through this cordon. However, he managed to do so, at one time slipping and nearly being thrown down a precipice. His hair-breadth escapes from soldiers looking for him were amazing, and it is not surprising that he came to think he had a charmed life. Sometimes he went forty-eight hours without food.

At last two vessels were fitted out at St. Malo towards the end of August, and on September 6th, 1746, they arrived at Lochnanuagh. News was conveyed to the Prince, and on September 20th he managed to get on board one of the ships, with 23 fugitive gentlemen and 107 men of common rank. The ships sailed away, and Charles's five months of wandering as a proscribed fugitive were nearly over.

He got safely to France, and with him went the last hope of the Stuarts. England might well be glad that she had seen the last of them, for from the moment that James I mounted the English throne they had been nothing but a curse to the country.

Charles's after story is a sad one. He frittered away his life, became a drunkard, ill-treated his wife so that she had to leave him, and died unhonoured and unsung at Rome in 1788. But he will always live in history as Bonnie Prince Charlie.

THE IMPORTANCE OF THE SAFETY-VALVE

If it were not for the safety-valves on the boilers that supply the steam to work our steam-engines there would undoubtedly be many disastrous accidents. Even the domestic boiler in the kitchen must have a safety-valve if all danger of explosion is to be avoided. Here we read about the safety-valve and its construction

To work a steam-engine it is not sufficient to have a closed vessel in which, by means of heat, water is turned into steam The boiler must be fitted with various devices such as a water-gauge to show the level of water in the boiler, a steam-gauge to show the pressure of the steam, and a safety-valve to allow the steam to escape when the pressure rises beyond the safety limit.

When a boiler is designed for a particular purpose it is made strong enough to allow the steam to reach a certain pressure such as is needed to work the engine. The sides and ends of the boiler are so constructed that they can resist this pressure, and in order that there may be a margin of safety they can always resist a pressure a good deal beyond this

But if the pressure were to rise enormously as it might do under certain conditions of heat, the boiler would explode How is this possible catastrophe avoided? Well, the boiler has attached to it a steam-tight valve which is kept down with a pressure equal to that of the greatest working pressure of the steam inside the boiler. When the pressure exceeds this prescribed limit the valve opens, steam escapes, and the pressure is relieved.

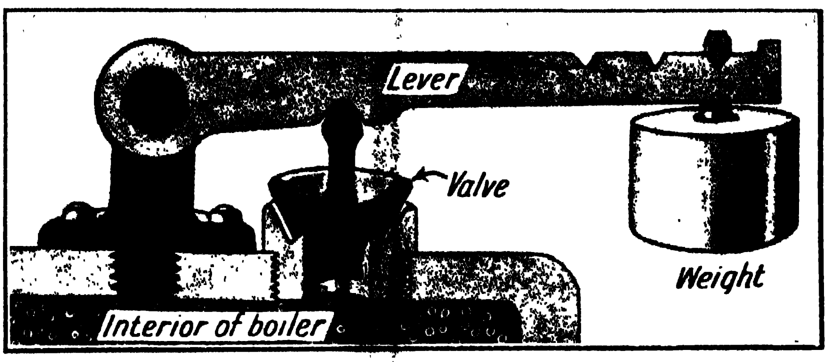
We little realise the enormous energy of steam. Professor Thurston has told us that a cylindrical boiler in which the steam exerts a pressure of a hundred pounds to the square inch has enough energy stored up in it to hurl the boiler straight up into the air for a distance of three and a half miles.

There are many kinds of safety-valves for boilers, some of them being very elaborate and complicated. In one kind there are springs to keep the valve closed under normal conditions. When the steam exceeds the proper pressure the valve is opened by the spring being pressed up

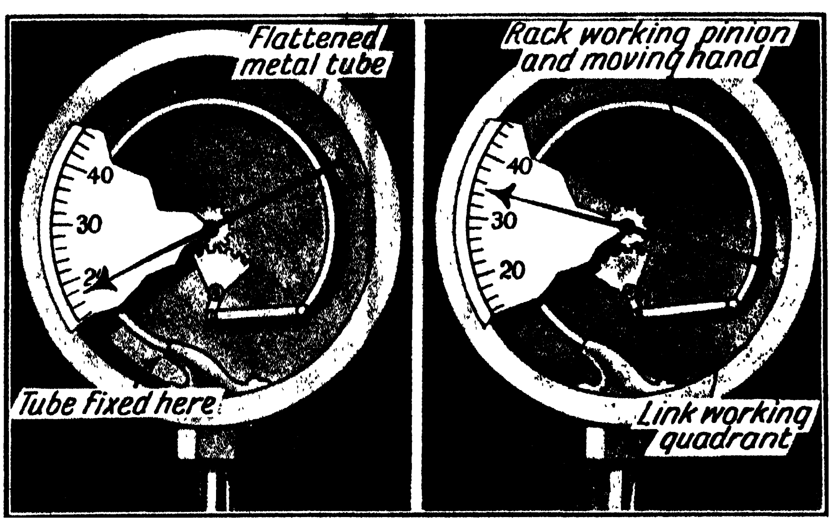
To give a drawing of a complicated steam-valve would be too technical to be interesting to ordinary people, but we give on this page a drawing showing the principle of a very common form of valve known as the lever safety-valve. In this type the valve is kept closed by a weight on the end of a lever, the weight being sufficiently heavy to hold the valve in position against the normal pressure of steam.

If, however, the steam exceeds this pressure, it is powerful enough to push up the valve, lifting the lever with its weight, and then the steam can escape and relieve the pressure in the boiler, thereby insuring safety.

It is, of course, important that an engineer should be able at any moment to know the pressure of steam which is being produced in the boiler, and so a steam-gauge is fitted.



This picture shows the principle of the lever safety-valve for a boiler. At normal pressure the weight on the end of the lever holds the valve in its seating, closing the opening. If, however, the steam pressure rises it lifts the lever and weight, and steam escapes through the valve opening, relieving the pressure

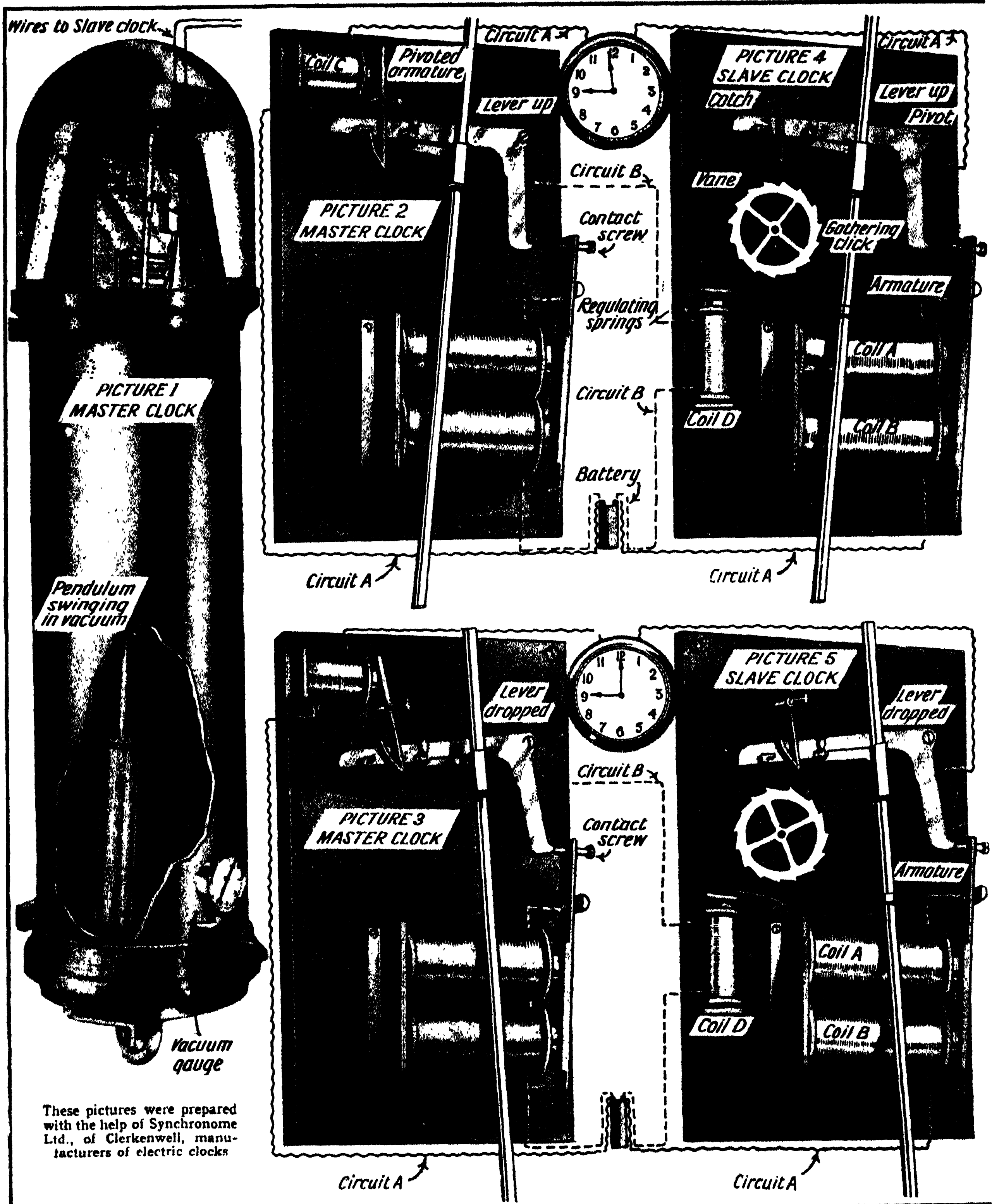


These pictures show the principle of a common type of steam-gauge. When the pressure in the boiler rises, the steam passing into the curved metal tube moves it outward, and as it moves it works a toothed rack which turns a wheel and moves a hand over the dial, showing the actual pressure in the boiler

Here, again, there are many types, but a common form is known as the Bourdon steam-gauge. In this a curved metal tube has one end closed and the other end, which is open, connected with a pipe leading to the inside of the boiler. The closed end is fastened to an arm which works a toothed rack engaging with a small pinion wheel This wheel works an indicator hand moving over a dial. As the steam pressure increases steam enters the curved tube and tends to straighten it, working the rack and pinion and turning the hand so that it indicates on the dial the steam pressure.

If we attach a piece of rubber tubing to a bicycle pump and curve the tubing round, when we work the pump the air pressure will blow the tubing straight. This principle is used in the Bourdon gauge.

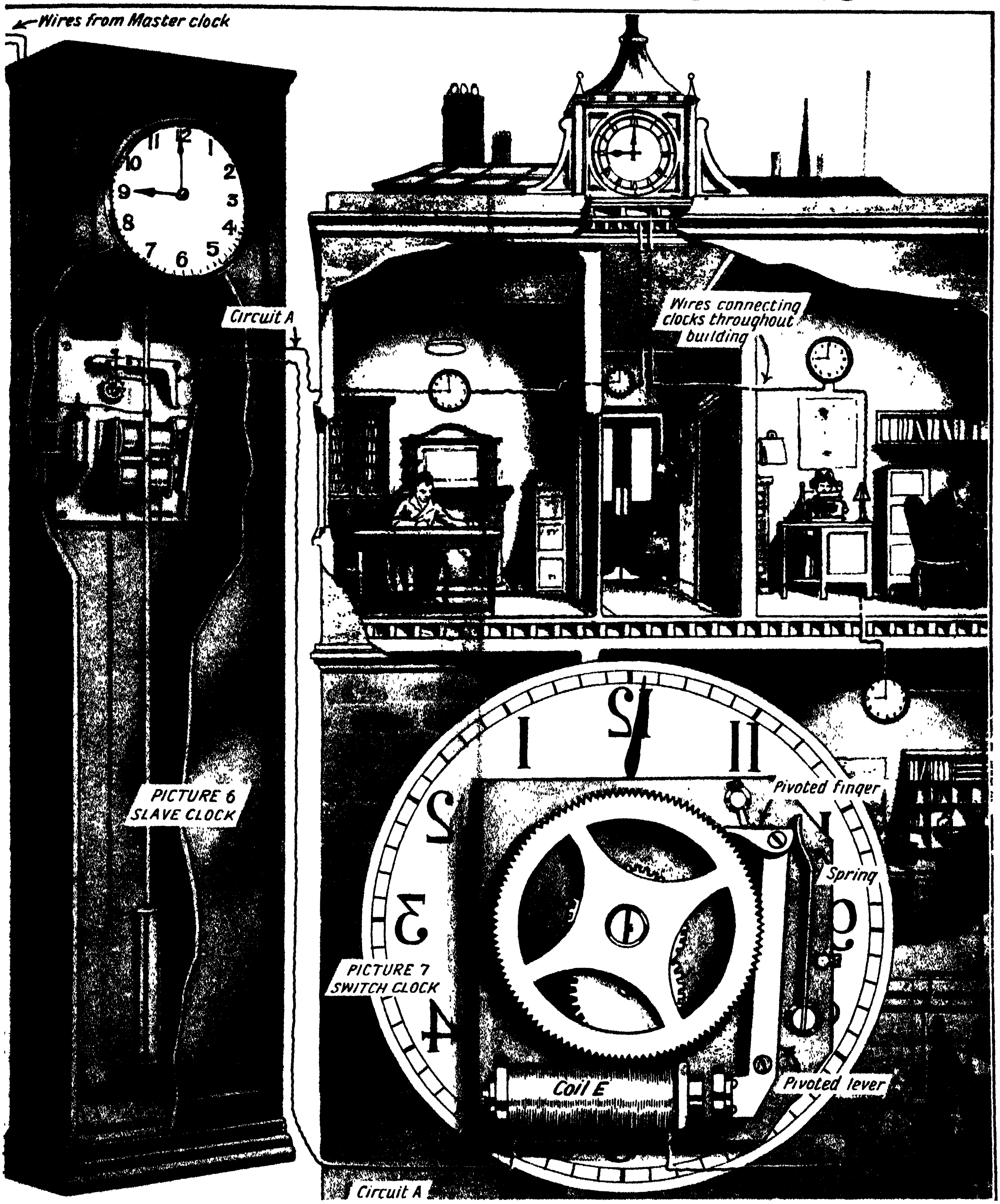
HOW THE ELECTRIC CLOCK IS ABLE TO



These pictures were prepared with the help of Synchronome Ltd., of Clerkenwell, manufacturers of electric clocks

All large modern buildings are now fitted with electric clocks. Somewhere in the building is a central clock, which gives the time, and this is connected by wires to any number of switch clocks or receiver dials in the rooms and corridors. Here we see how the system works. On the left, in Picture 1, is the master clock, with its pendulum swinging freely in a vacuum, so that it is not affected by the air. This keeps correct time. From there any number of central clocks in buildings all over London can be controlled. These are known as slave clocks. The master clock, one of which on account of its accuracy is installed at Greenwich Observatory, is merely a pendulum, which swings in perfect time. On the slave clock, shown in Picture 6, and on a larger scale in Pictures 4 and 5, there is a wheel with fifteen teeth, and as this clock's pendulum swings to the left a little arm called a gathering click, attached to the pendulum, engages with one of the teeth of the wheel. When the pendulum swings to the right, as in Picture 5, it pulls the wheel round, and after swinging to and fro thirty times, that is, half a minute, a vane fixed to the toothed wheel knocks against a catch, which is holding up a pivoted lever. The lever thereupon drops, and its lower end touches the point of a screw on a magnet armature, and completes the circuit marked A. When circuit A is completed, coils A and B in the slave clock and coil C in the master clock (see Pictures 2 and 3) are energised. The magnet in coil C now attracts a pivoted armature, causing a lever to drop,

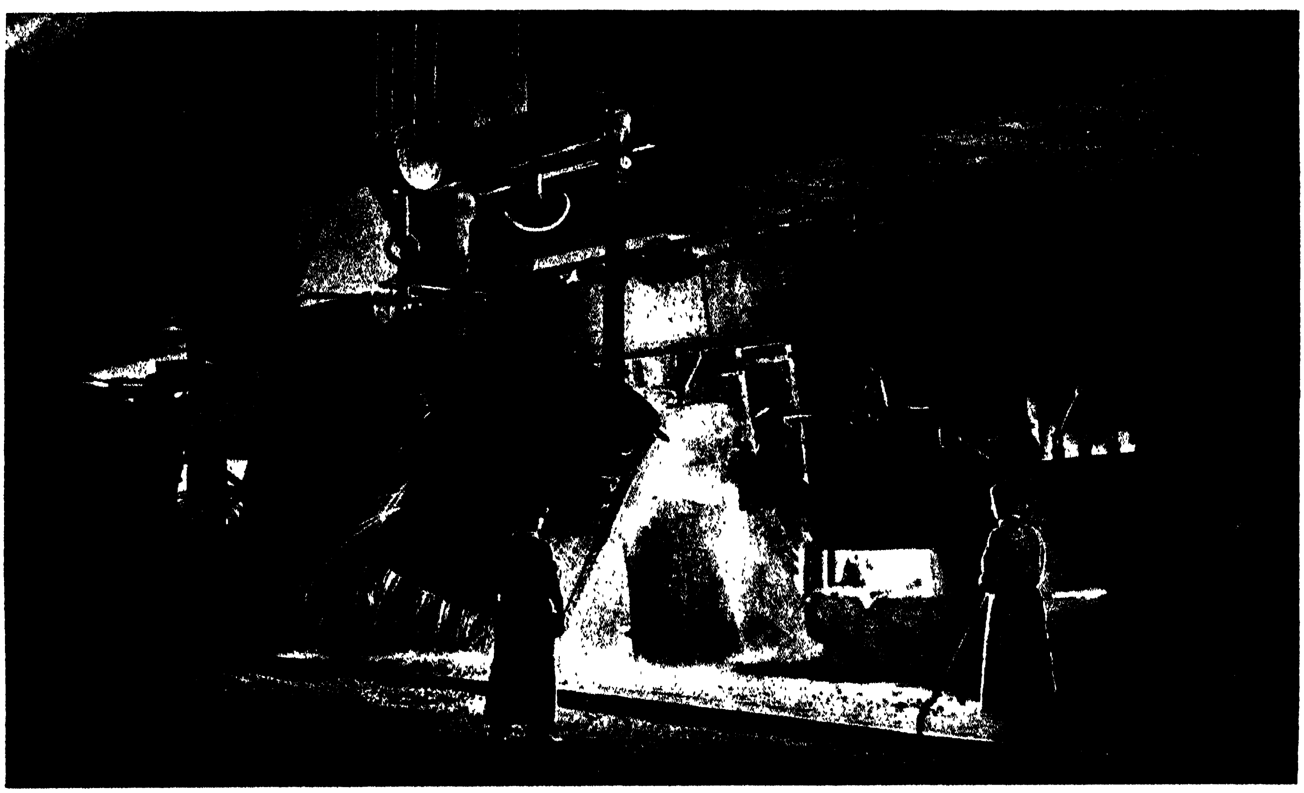
WORK MANY DIALS IN ONE BUILDING



and its end on touching a screw completes circuit B. The effect of this is to energise coil D in the slave clock (see Pictures 4 and 5) and this draws down an armature, to which is attached a piece of spring. The spring just touches another spring attached to the pendulum, and if the slave clock's pendulum should be just a fraction behind the master clock's pendulum, this spring or armature, in coming down, will engage and gently press the spring on the slave clock's pendulum, giving this pendulum a slight push, speeding it up. When coils A and B are energised and draw the armature to them, the contact screw strikes the end of the lever sufficiently hard to drive it up ready for the next displacement of the catch. The current is thus broken almost immediately it is made. When circuit A is completed in the slave clock it energises coils in any number of switch clocks all over the building. The back of one of these is shown in Picture 7. The completion of the circuit energises coil E and a pivoted lever is attracted, the upper end of which has a finger, engaging the teeth of a wheel. The attracting of the lever by the magnet in coil E pulls the finger away from the tooth, and it drops on to the next tooth. The current now being broken, as explained in the description of Pictures 4 and 5, a powerful spring pressing on the finger forces it to push the cogwheel round one tooth. This movement takes place every half-minute, and there are therefore 120 cogs on the wheel. The hour hand of a switch dial is worked by being geared to the large minute wheel

CHARGING THE FURNACE WITH METAL

The making of steel, like all other processes, has been enormously speeded up in recent years. Nowadays the charging of the furnace is carried out by means of elaborate and costly machinery. In this picture we see a great apparatus worked by electricity inserting a slab of steel in a re-heating furnace. Steel bars made from ingots when they are to be rolled out still farther are first re-heated



Here we see a steel tilting furnace being charged with molten iron. The process shown is not the Bessemer process, but the open hearth method of making steel. It is less expensive than the Bessemer, and now produces much greater quantities of metal than that process. The furnace can be fed with cold pig iron, or, as here, with molten iron

WONDERS of ANIMAL & PLANT LIFE

THE STRIPED TERROR OF THE JUNGLE

The tiger, although it is also a member of the cat family, varies a good deal from the lion in external appearance. Its skeleton, however, is so much like a lion's that only an expert could distinguish it. It is difficult to say whether fossil skeletons that have been found in Britain and elsewhere are those of lions or tigers. We read in these pages many interesting facts about the tiger

THE lion and the tiger are both members of the cat family to which our domestic cat belongs, and they are very closely related Indeed, apart from their skins there is very little difference in the physical construction of the lion and tiger, and it would take an expert to tell their skeletons apart except, perhaps, by a comparison of their skulls.

In Great Britain, as well as in Europe Asia and America, there are found the fossilised bones of an animal of the cat family which lived in past ages. It is generally called the "sabre-toothed tiger," but while many men of science call it a tiger, others think it would be more accurately described as a lion This shows how very alike in construction, if not in outward appearance, lions and tigers are.

The tiger, however, is a much more powerful, and a fiercer animal than its cousin the lion. Men who have taken travel films in Africa in recent years tell us that, except when they are hungry, lions are not very formidable creatures at all.

Of course, all animals, including men, are fierce when they are hungry. But the tiger is a dangerous animal to meet at any time, and if it is a man-eater, that is a tiger which has acquired a liking for human flesh, it is such a danger that it will terrorise a whole district.

Distinctive Stripes

No one can mistake a tiger for any other animal Its size and its handsome striped coat mark it off from all other members of the cat family Of course, when well fed in a zoo cage or den it looks a very nice animal, and little tigers might seem delightful pets, but as they grow up they are anything but delightful, and cannot be trusted.

The tiger is quicker in its movements than the lion and much more sly and cunning. Experts declare that even a well-armed, well-trained and experienced hunter is no match on foot for a tiger, but the Masai warriors of Africa often meet and vanquish a lion on foot with no other weapon than a spear

While the lion is a creature of the grassy plains, of a tawny colour matching well with the scorched grass, the tiger is a creature of the mountains and forests rather than of the open lands This seems strange, for its colouring suggests that its home is the jungle, where the black stripes on a yellow ground camouflage the animal excellently in the tall grass on which the sun is playing and casting shadows.

Yet scientists tell us that it is really a creature of the cold climates, and that it is far more worried by heat than by cold Cats do not like water, but the tiger likes it and swims well.

We generally think of the tiger in connection with India, but it is also found in parts of Siberia, China, Manchuria and Korea Its tracks are often traced in the snow, and in the severe winters of the North it frequently crosses over the frozen sea from the mainland of Asia to the island of Sakhalin. Many a traveller in the snows of Siberia and the mountains of Turkestan has been slain by a tiger, where he least expected to meet this animal Some years ago a Kirghiz prince was travelling with his bride in the Altai Mountains, when the princess was suddenly pounced upon and carried off by a tiger

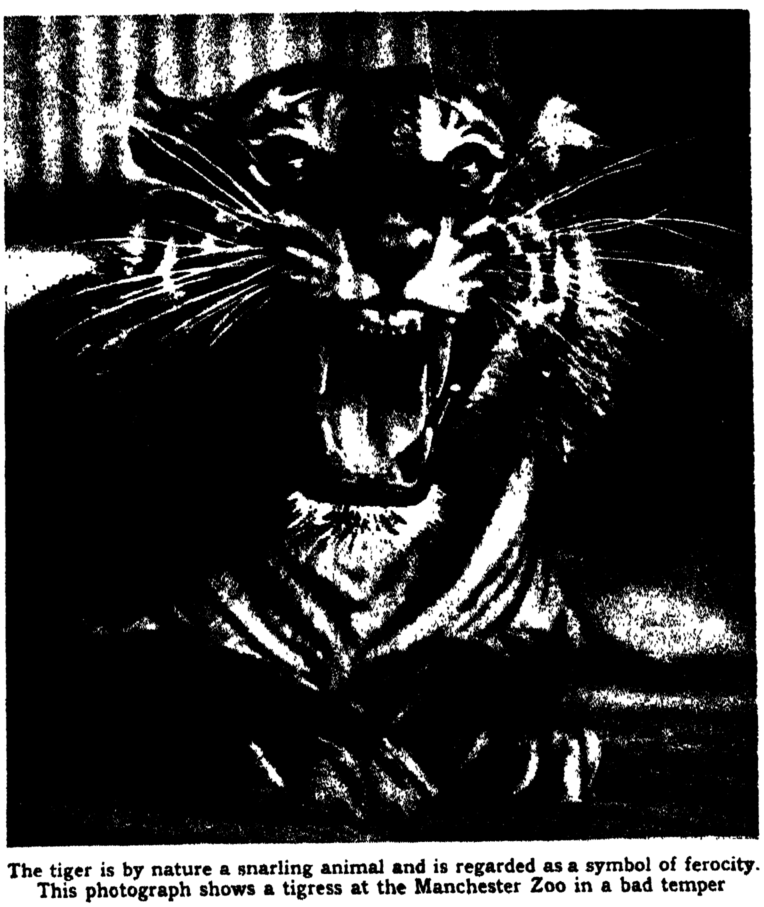
The animal always seems to be more at home in these colder climates than it does in the hot lands of India. Its feet get tender if it has to walk far on hot, sandy ground, and it is a thirsty animal which must have ample supplies of water to keep it healthy

It is said, not without reason, that the tiger has seized the imagination of mankind as the symbol of ferocity and cruelty. It is a snarling beast, and hangs about the jungle villages of India to prey upon the flocks and herds of the people If these try to defend their animals they are ruthlessly slaughtered

A Deadly Menace

Having once tasted a human being, the tiger may become a "man-eater," and will henceforth lie in wait for men, women and children, killing them off as they go about their daily work.

All European hunters agree that the man-eating tiger is a very wary animal and most difficult to kill. It seems to acquire an added cunning, so that it can baulk those who are searching for it. Many a time has the hunter become the hunted, and fallen a



The tiger is by nature a snarling animal and is regarded as a symbol of ferocity. This photograph shows a tigress at the Manchester Zoo in a bad temper

THE MAJESTIC TIGER ASLEEP AND AWAKE

The tiger, although it lacks the fine mane of the lion, is certainly a majestic-looking animal. It grows to a length of six feet or more, and the tail adds another three feet. Sometimes, however, specimens have been found nearly ten feet long, including the tail, and weighing nearly five hundredweights. The female animal is about a foot shorter than the average male. Tigers living in Siberia have longer and shaggier hair than their relatives found in hot countries like India. We do not generally think of the tiger as living among the snows, but, as a matter of fact, it seems happier in cold regions than in those which are very warm. In winter it sometimes makes its way across the frozen sea from Siberia to the island of Sakhalin. Although naturally a fierce animal, it looks benevolent enough when asleep Evidently the sparrow thinks so, for it is calmly pecking at some tit-bit a yard from the tiger's mouth

The tiger is certainly a fine-looking animal when well cared for in captivity like this specimen in the London Zoo. Its colour varies from pale reddish to brownish yellow, with the underparts of the body often white. Head, body and limbs are marked with very distinctive transverse black stripes, and the tail is ringed with black. The ears also are black, except for a white spot. White and black tigers are occasionally found in which the spots are almost invisible. The colours of the animal are always brightest in youth, and get less distinct with advancing age. The tigers living in forest regions are reddest. The Manchurian tiger has more white on its face than the Bengal tiger, and in winter develops a long, thick, woolly coat, whereas the Bengal tiger's coat has no marked lengthening in winter

A TIGRESS GOES FOR A SWIM IN THE RIVER

The tiger is fond of the water and sometimes lies in cool, shallow pools and rivers. It is also an excellent swimmer, and in this remarkable photograph, taken by Captain Norman Franklin in a game reserve belonging to the Nizam of Hyderabad in India, we see a tigress swimming in a river while her mate keeps pace with her on the bank. Captain Franklin dressed himself in leafy branches to look like a tree so that the tigers might approach near enough to be photographed. A buffalo's carcass was placed close by as bait. This and other photographs were taken successfully, but the captain ran a great risk, for he carried no arms but a revolver. In the more thickly populated districts of India the tigers have greatly decreased in numbers in modern times. In some areas, indeed, they have disappeared, but in the less inhabited districts they are still plentiful, and are abundant in areas where forest and grass jungles remain

victim to the very animal whose life he was seeking

Sir Samuel Baker, the great traveller, tells a very thrilling story about such an incident He says that in the Nagpur district a tigress had killed so many people that a large reward was offered for her destruction The body of her last victim had been left uneaten, and a number of native hunters, considering that she would probably return to her prey during the night if it were left undisturbed, made their plans accordingly

There were no trees or any timber that was suitable for the construction of a machan, that is, the raised platform from which hunters watch for a tiger, so it was decided that four deep holes should be dug, forming the corners of a square, in the middle of which the body of the man could remain.

Each hole was occupied by a hunter with his loaded matchlock, but nothing happened, and at length the moon went down and the night became pitch dark The hunters were not very happy, but they were afraid to get out of their hiding-places and walk home through the jungle in case the man-eater met or followed them and did her fell work once again They therefore remained in their holes, where some of them, after a time, fell asleep

At last daylight broke, and three of the hunters came from their hiding-places, but great was their consternation when it was found that the fourth had disappeared; his hole was empty Not far away his matchlock was discovered on the ground, and there were the tracks of the tigress, with the sweeping trail made by the poor man's body as the man-eater had dragged it along The track was followed, and the remains of the unlucky hunter were found, partly devoured.

The whole district was up in arms against this terrible tigress, but it was not until twelve months later that she was at last shot, having meanwhile devoured many other natives, both men and women

Killing By Sheer Weight

When it is remembered that the tiger may weigh as much as four hundredweights or more and springs with enormous velocity, it can be understood that its attack is terrible. When bringing down a bullock, however large, it invariably breaks the animal's neck by mere weight. It does not generally strike, as a lion does, but merely seizes with its claws, using them to clutch and lacerate its victim.

There is one attractive feature about the tiger, however, and that is the mother love of the female. She rarely has more than two cubs at a time and looks after them till they are full grown, which is at about two years of age She teaches them most skilfully to kill their prey, and hunters have seen a tigress go to a tied-up buffalo with her cubs and show them again and again how to attack the animal.

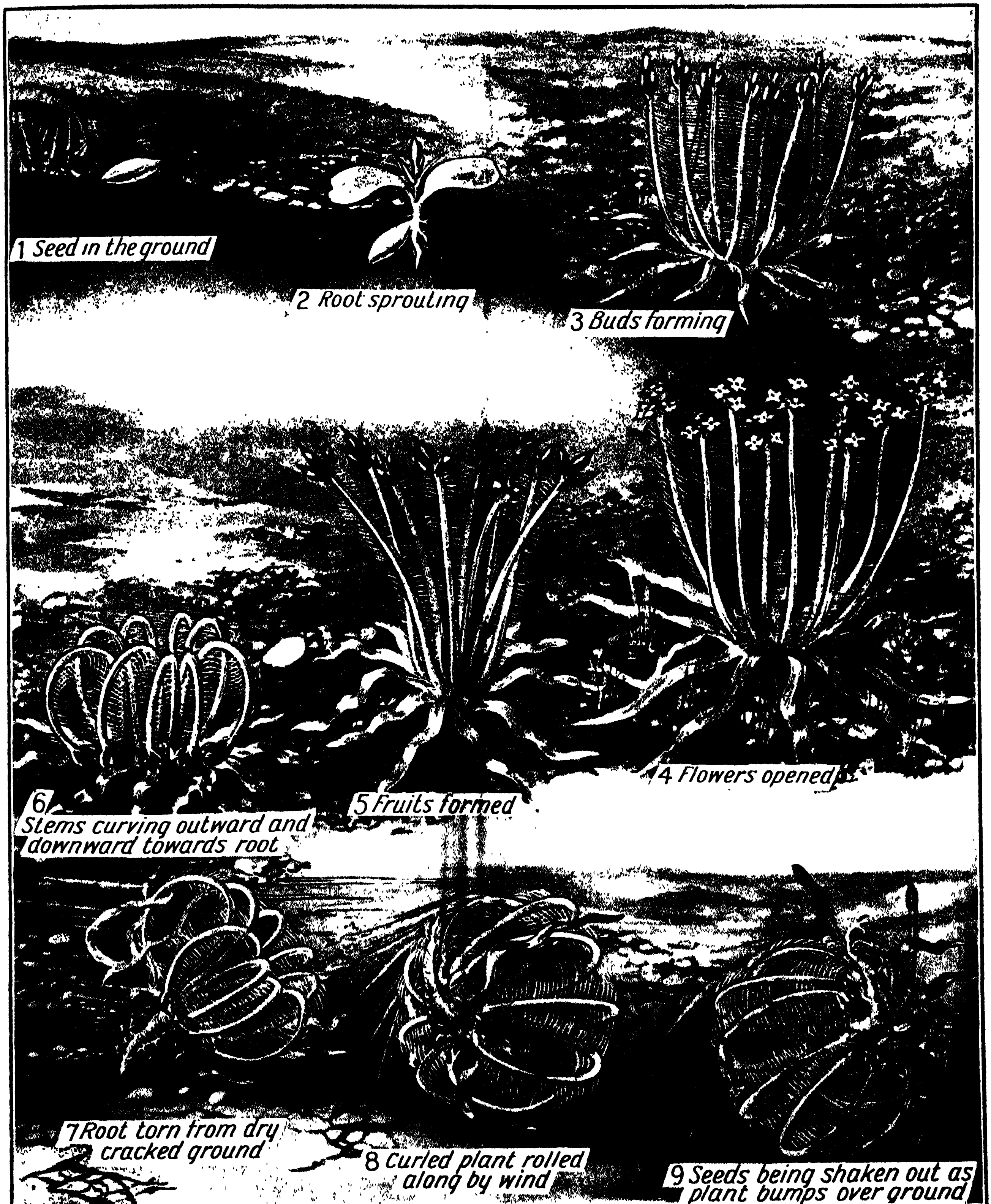
Those tigers which live in the north where snow is common are much lighter in colour than those of the hot jungle lands. From time to time remarkable specimens are taken both white and black. In these the stripes are only faintly visible

The full-grown male tiger is generally about six feet long from the tip of the nose to the root of the tail, and the tail adds another three feet to the length But sometimes larger specimens are found The female is about a foot shorter than the male. An average male weighs about 350 pounds, but specimens are said to have been shot up to 500 pounds. One is recorded that measured nine feet ten inches, and weighed just over 495 pounds.

Mr G. P Sanderson, one of the greatest authorities on the wild beasts of India, tells us that the largest tigers are found among habitual cattle killers. "When a tiger becomes old and fat," he says, "he usually settles down in some locality where beef and water are plentiful, and here he lives on amicable terms with the villagers, killing a cow or bullock about once in four or five days Some tigers contract the habit, through being interfered with, of killing more than one animal in each attack. I have seen three, four and five cattle on the ground together after attacks by single tigers, and on one occasion fourteen killed by one tiger in a herd overtaken by a storm; many of the cattle were benumbed and unable to escape"

The tiger may weigh four hundredweights or more and it springs with enormous velocity, so that the force with which it strikes its victim is almost irresistible In this it is a more formidable foe than the lion

A PLANT THAT GOES FOR A WALK



On this page we see the life-story of the plantago, a plant which grows on the Steppes of Northern Asia. The seed sprouts and develops into a compact plant with a main axis from which springs a tuft of stiff stems. In due course buds appear and open into flowers which later produce fruits. As the fruits begin to ripen the stems of the plant curve downward and outward, and in doing so give a wrench to the short stem and tap root. The soil is at this season very dry and cracked, and when a strong wind comes the plantago is uprooted and rolled along the ground. On and on it goes, dropping its seeds as it travels and thus spreading them over a wide area, where the young plants, when the seeds germinate, have a better chance of getting nourishment, as they are not crowded by other plantagoes

THE GIANT CAMERA THAT TAKES THE STARS

The adaptation of the camera to the telescope marked as great an advance in the study of the heavens as the invention of the telescope itself. The record of the stars on a photographic plate is permanent and can be multiplied indefinitely so that copies can be sent to astronomers in every country for examination at their leisure, whereas a visual image seen only with the eye looking through a telescope is transient. Further, the photographic plate can store up light so that a star too faint ever to be seen with the human eye can, by a long exposure, be recorded on the plate. Here we see the giant astronomical camera at the Norman Lockyer Observatory at Sidmouth. The instrument consists of four cameras of different focal lengths, with clockwork mechanism to follow the stars during a long exposure

WONDERS OF THE SKY

PHOTOGRAPHING THE HEAVENS

It has been said that if the telescope is an enhanced eye-lens, the photographic plate may fairly be regarded as a new retina. Photography is of enormous value in studying the heavens, for what the human eye cannot see the photographic plate can record. It is due to photography, which has brought to our knowledge myriads of stars, that we now have some idea of the shape and extent of our Milky Way universe. Further, we now know, thanks to the camera, that there are thousands of other similar universes incredible distances away

ASTRONOMERS are often called star-gazers, but the astronomer of to-day spends very little of his time gazing at the stars through a telescope. Instead he uses the photographic plate as his "eye," and in this way he is able to see far more of the universe than he would be able to see if he looked up at the sky through a telescope.

There is a very definite limit to what can be seen even through the most powerful telescope, for the human eye itself is limited. When, however, sensitive photographic plates are used in conjunction with the telescope, there seems hardly any limit to what can be discovered in space so distant that it baffles our imagination to conceive it.

So important is photography as the handmaiden of astronomy that to-day there is scarcely an observatory that is not provided with the equipment for taking photographs of the heavens. Thousands of plates are exposed every year, and one great advantage of this method of observing the heavens is that from the plate any number of prints can be taken, and sent to astronomers in all parts of the world for their examination.

Another great advantage of photography in the studying of the stars is that myriads of bodies in distant space which are too far away ever to be seen with the human eye can be recorded on the photographic plate. Insufficient light reaches our Earth from them to enable it to make a record on the retina of the eye in the few minutes or so over which observation lasts.

But the photographic plate knows nothing of fatigue, and when it is exposed for four or five hours or even more the stored-up light from the distant star or nebula is sufficient to impress the plate, and we are thus able to see myriads of stars and nebulæ which, without photography, would for ever remain invisible.

Keeping the Telescope Pointed

Of course, in giving these long exposures it is absolutely essential that the telescope should move round on an axis in a direction opposite to that of the Earth's rotation, so that the point of the heavens being photographed may remain stationary, relative to the telescopic lens and photographic plate.

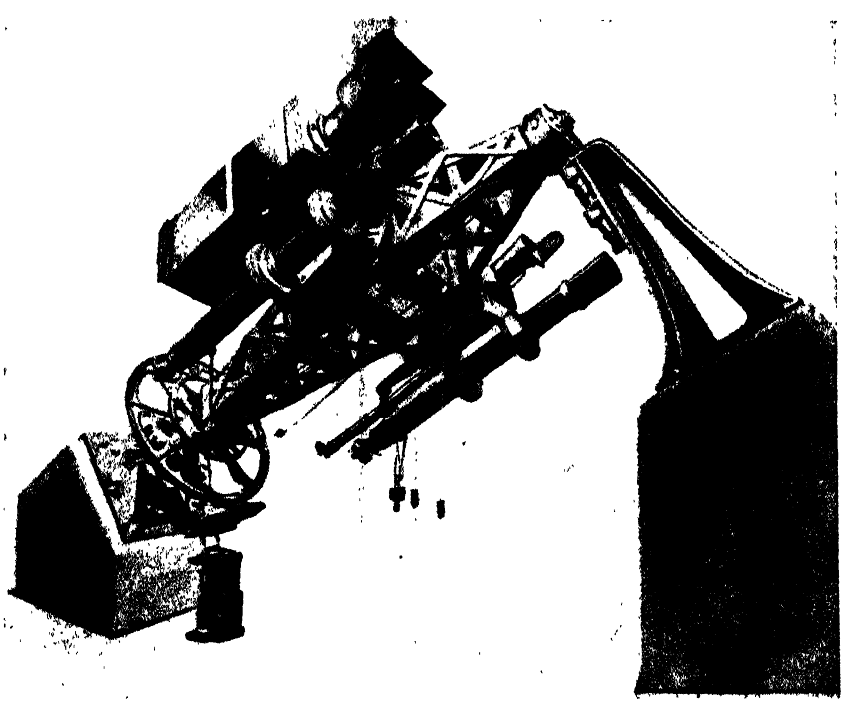
This is done by means of very elaborate and accurate clockwork. If the clockwork were incorrect in the minutest degree the photograph, after long exposure, would give nothing but a blurred image. Indeed, it is the custom when these long exposures are being made for the astronomer to examine the object with the eye from time to time to see that there is no irregularity in the telescope's movement.

Many objects suspected but unseen have been found by means of the camera linked with the telescope. For example, when it has been thought that a comet was due to appear the apparatus has been turned towards that part of the heavens where the comet was expected, and in many cases the developed plate has revealed its appearance. Halley's Comet, for example, at its return in 1910 was first found upon a photographic plate. Several satellites in the solar system have been discovered in the same way.

Another example of the value of photography in astronomy was proved when professor Barnard found a famous "runaway star," that is, a star which had a motion far exceeding anything known in other stars. The motion was discovered by comparing various photographs taken over consecutive periods.

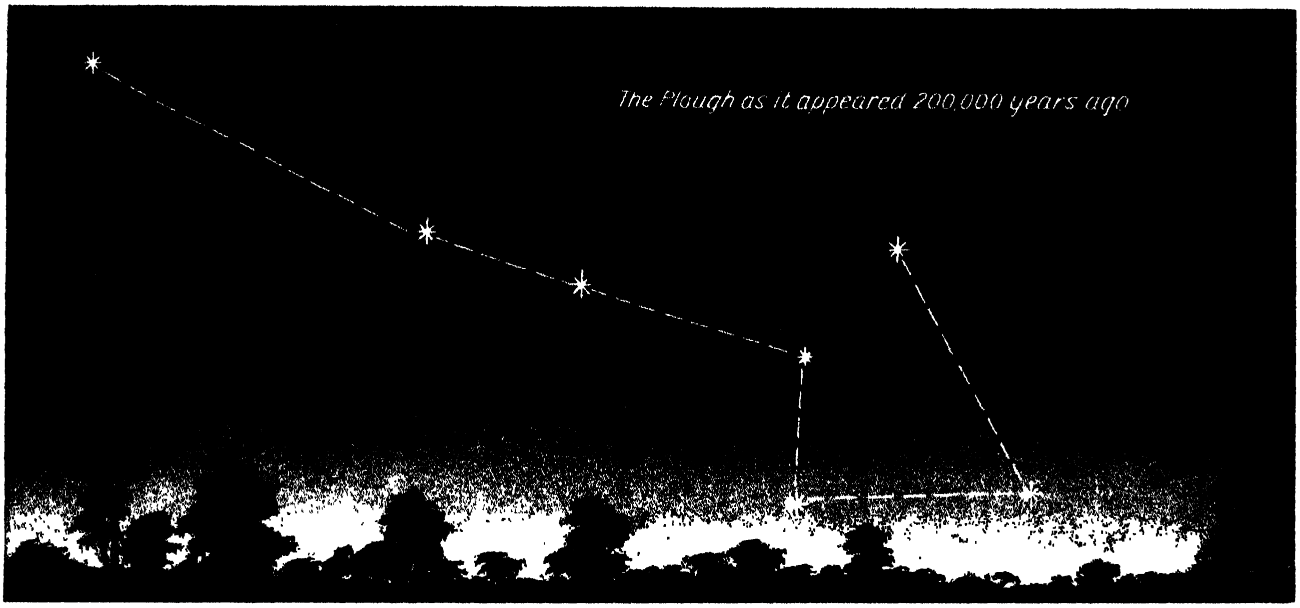
While much increase of knowledge results from these photographs even in our own day, perhaps the greatest advantage will come when whole series of photographs taken throughout a century or more are compared. If only our forefathers had had photography and had left us photographs of the sky we should know much more to-day about the heavens than we do.

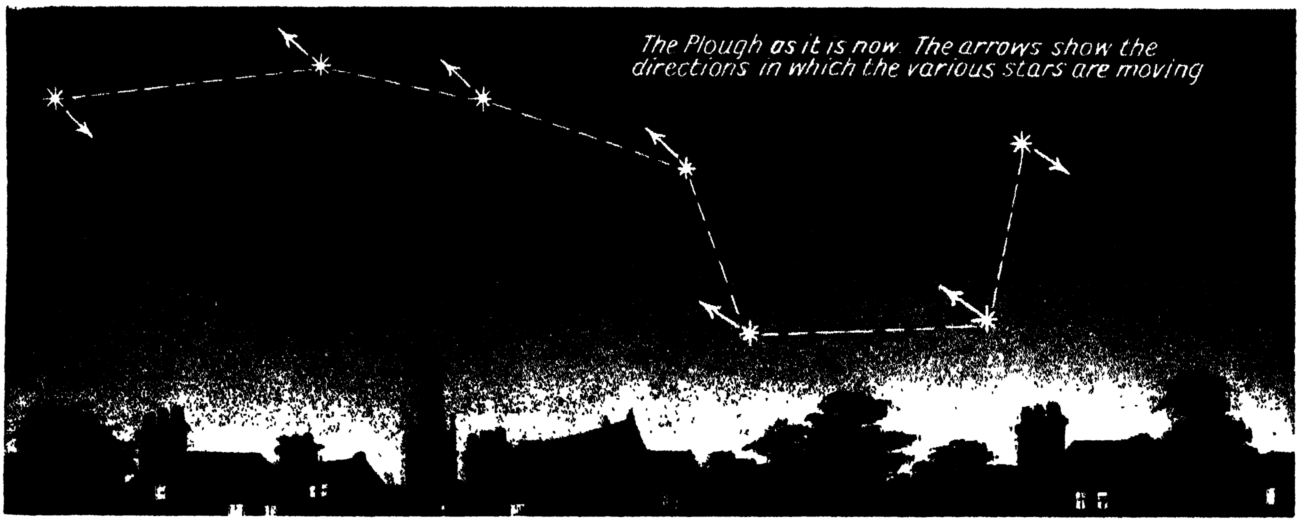
The photographic plate is also used in connection with spectroscopic work, and four-fifths of this important branch of astronomy is now done by means of photographs of the various spectra. With plates sensitive to the ultra-violet rays far more of the spectra of the stars can be detected than would be possible without the invaluable aid of telescopic photography.

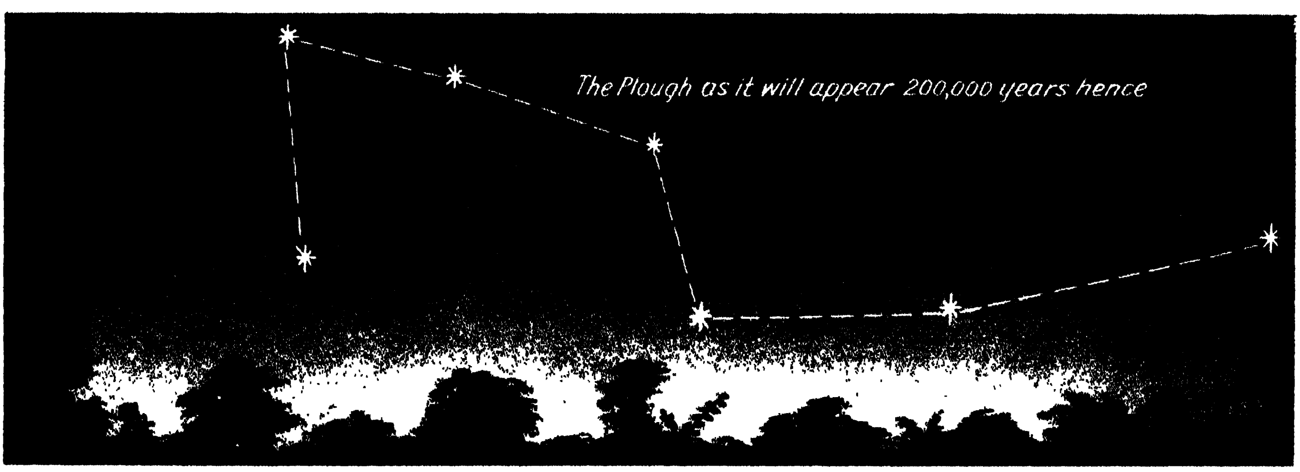


Here is the wonderful Franklin-Adams astro-camera with which are taken remarkably clear photographs of the universe round about us, as seen from the Southern Hemisphere. This camera is at Johannesburg Observatory, South Africa, and the picture is given here by courtesy of the Royal Astronomical Society

HOW THE PLOUGH IS CHANGING ITS SHAPE







The plough, part of the Constellation of the Great Bear, is the best known group of stars in the sky. Its shape is now remarkably like a plough, but it was not always so and in years to come it will have again changed very much so as to bear little resemblance to its present form. We speak of the "fixed stars," but the stars are by no means fixed ; all are travelling at enormous speeds. The stars of the Plough, however, are not all moving in the same direction, and so in the course of thousands of years the shape that they now form will be altered. We see in these pictures the Plough as it was, as it is, and as it will be

WONDERS of LAND & WATER

WHY THE SKY IS BLUE OVERHEAD

We all know how blue the sky is on a fine summer day. But why is the sky blue? If we were on the Moon and looked up in the daytime we should not see a blue sky, but a black one, with the stars and the Sun shining brightly down. It has long been known that the blueness of the sky was due to our atmosphere, but here we read about the latest discovery in connection with the matter

THE colour of the sky on a fine day, except near the Sun and the horizon, is a rich blue. Why is it this particular colour, and not, say, red or yellow?

Of course, our ordinary daylight is not blue, but white, and very often it does not appear to come from the Sun at all, but to be diffused throughout a room. The window may not face the Sun at all, and yet the room is light. This we owe to the fact that the sunlight is reflected and bent by countless millions of particles in the air, so that the light goes in all directions. If it were not so we should be unable to see unless we were in the direct line of the Sun's rays. The light would not penetrate into all the corners of the room.

It is the particles in the air that diffuse or spread the light. Where there is no air there is no daylight. If we could go up above the Earth's atmosphere we should find a black sky everywhere, with the stars shining as points of light and the Sun a brilliant object sending out straight rays. Everywhere except in the direct line of light would be dark. There must be the atmosphere and the tiny solid particles in it if the light is to be spread.

The Dust Theory

Why is it, if the daylight is white, that we see the sky on a sunshiny day as blue? Well, until quite recently it was thought that the blue colour of the sky was due chiefly to the scattering of sunlight by the myriads of dust particles which are always present in the atmosphere. The longer waves, such as the red and yellow, it was said, managed to get through the mixture of air and dust particles, while the shorter waves, like the blue, were scattered, the result being that as we looked up at the sky we saw these scattered rays of blue.

But quite recently Professor Vigard, of Oslo University, has discovered that the prevailing blue of the sky is produced not by the dust particles, but by tiny crystals of frozen nitrogen in the upper atmosphere. These occur chiefly at two heights above the ground, namely, forty miles and a hundred miles, and are spread above the Earth's surface like blankets. They are known as the Heaviside Layers, and it is these which prevent the wireless waves that are broadcast from being lost in outer Space.

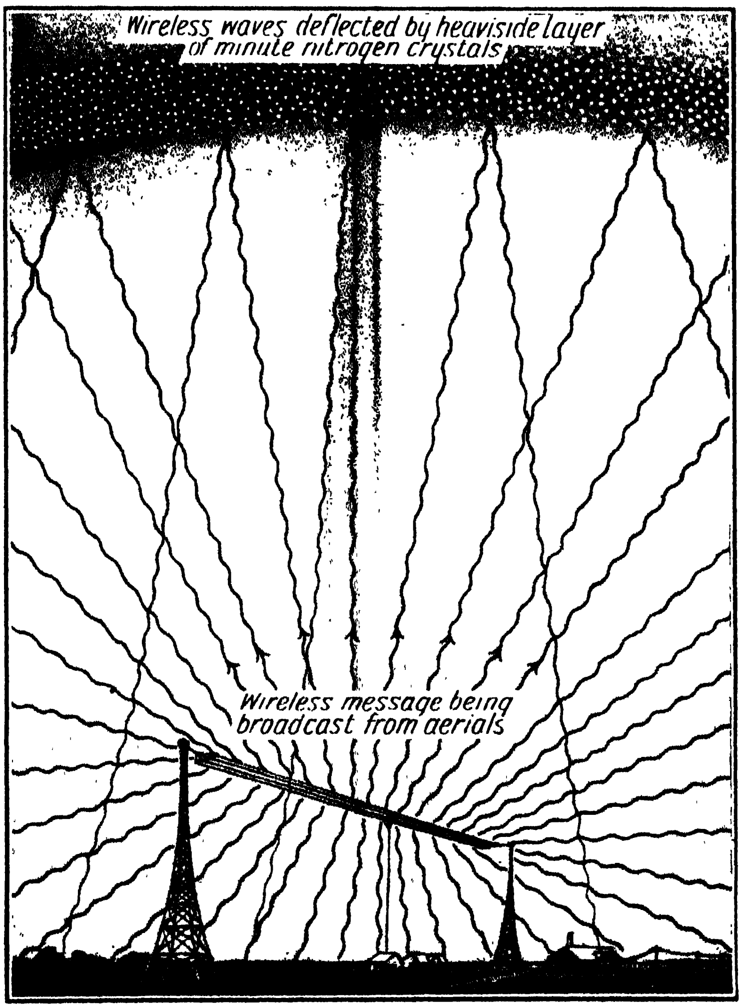
Another scientist, Professor Onnes, of Leyden, reduced nitrogen in a laboratory to a temperature of 378 degrees below zero, Fahrenheit, when it became crystallised, and produced the same light effects as the nitrogen crystals in the upper atmosphere. The nitrogen is lighter than the atmosphere, and that is why it floats above the ocean of air.

When we look upward the sky is always bluer overhead than it is when we look around nearer the horizon, and the reason for this is that the nitrogen particles nearest to ourselves are always overhead. The nearer the sky approaches the horizon the more we are looking at it through the denser lower layers of air. The result is that the sky is less blue near the horizon than above our heads.

A Monotonous Sky

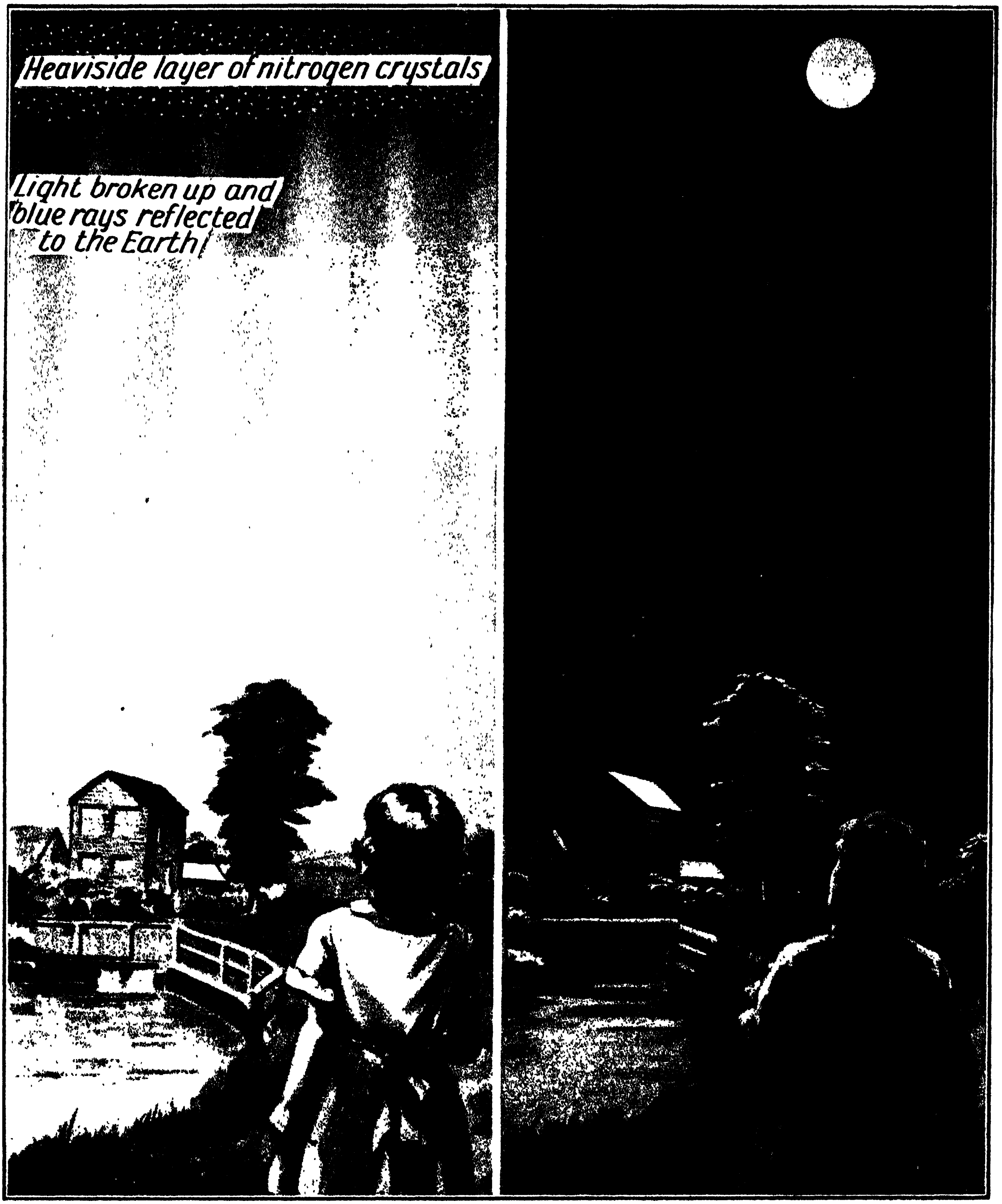
As the Sun sets and gets nearer the horizon its colour often becomes yellow or orange or even red. This is due to the particles in the atmosphere breaking up the light and allowing only the long waves, that is, those that are red, orange and yellow, to reach our eyes. The greater the thickness of atmosphere through which the Sun's light must pass to reach us the less of the shorter rays are able to get through.

How thankful we should be that the conditions of our lives include an atmosphere! We should find it very wearying and monotonous if during the daytime on looking up we saw nothing but a black sky with the stars and the Sun as bright objects, but no blue, and if there were no diffused light round about us.



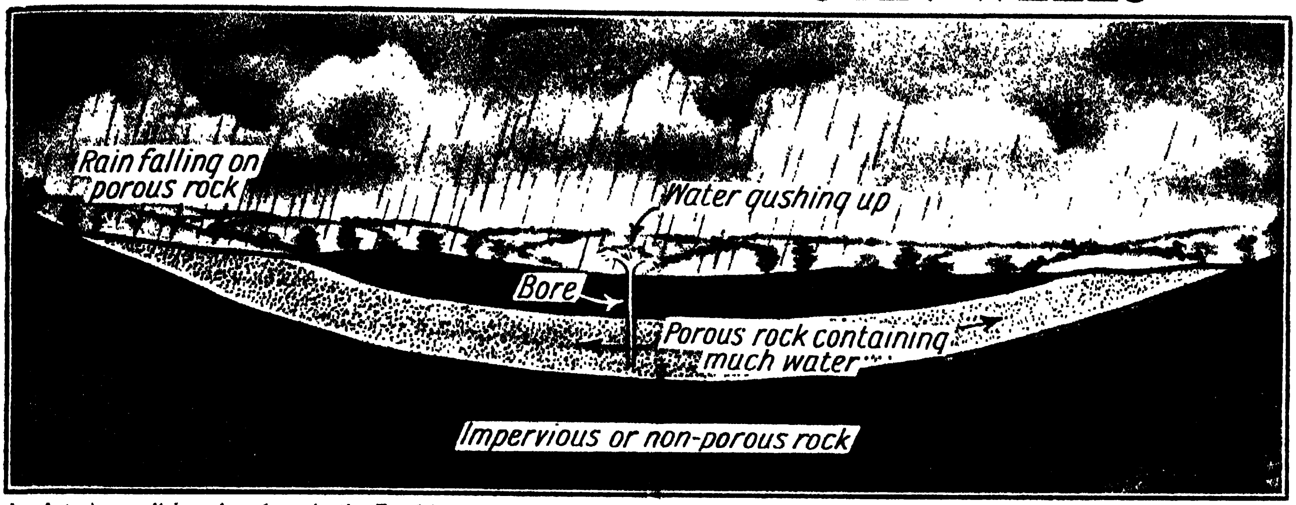
The heaviside layer of nitrogen crystals high up in the air, which prevent the sound radio waves from being lost in space. These waves are reflected by the layer and are thus able to pass round the world, as explained in page 1367.

HOW THE ATMOSPHERE AFFECTS THE DAYLIGHT

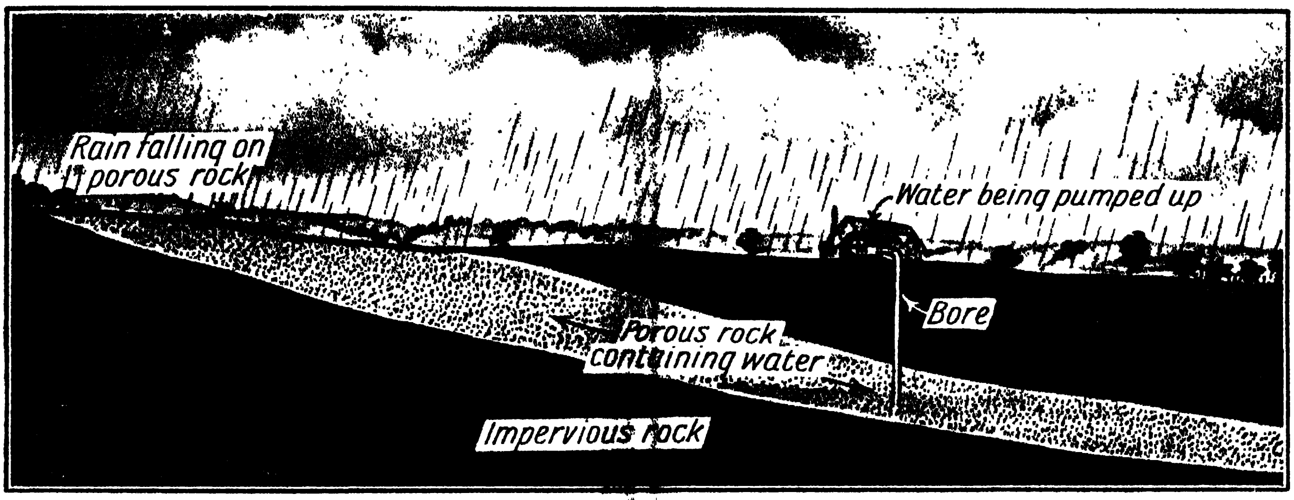


Daylight is due to the breaking up of the Sun's light and its reflection in all directions by particles in the atmosphere. If it were not for this diffusion the only objects illuminated would be those on which the Sun's rays fell directly. On the Moon, which has no atmosphere, the sky is nearly black in daytime, with the Sun and stars shining out brightly, and the landscape a vivid contrast of lights and shadows. The picture on the left shows our world as we know it, and that on the right shows what daytime would be like if there were no atmosphere. Nitrogen crystals high up in the air break up the light and reflect the blue rays to us, making the sky look blue. It was formerly thought that the reflection of the blue rays to us was due to numerous minute particles of dust in the upper atmosphere. But more recent discoveries have shown that it is the heaviside layer of nitrogen crystals that are really responsible for the colour. At the horizon the sky is less blue, and it is because we are there looking at the heaviside layer through a greater thickness of atmosphere

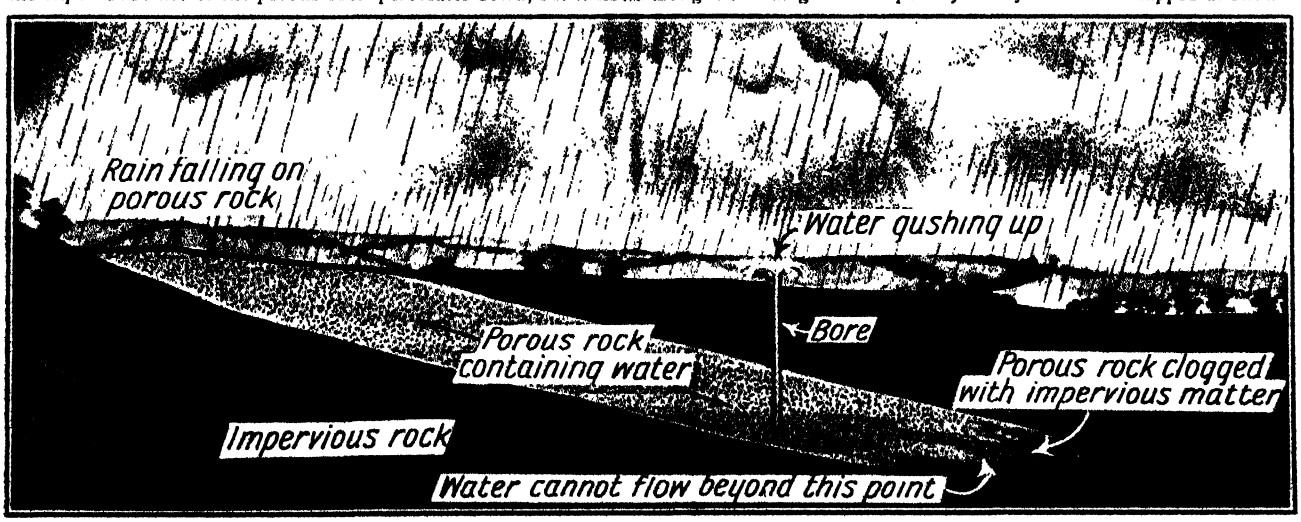
THREE KINDS OF ARTESIAN WELLS



An Artesian well is a deep bore in the Earth's crust through which a constant supply of water rises to the surface or sufficiently high to be pumped out economically. The name is derived from Artois in France, where such wells were sunk long ago. A gushing Artesian well occurs where the beds of rock slope first downward and then upward, forming a kind of basin as shown here. Rain falling on the exposed surfaces of the porous rock percolates through till it reaches the bottom of the basin above the non-porous rock. When a boring is made to this low level the water is forced up by the pressure of the water in the water-bearing bed at higher levels



Sometimes, however, as shown here, the water-bearing bed of rock does not form a basin but slopes only in one direction An Artesian well can be sunk there and water obtained, but it will not gush up. Instead, it will have to be pumped. In this case also the rain falling on the exposed surface of the porous rock percolates down, but it flows along the underground slope very slowly and can be tapped as shown



An Artesian well in which the water gushes up may sometimes be found even where the porous rock, instead of forming a basin, slopes only in one direction as in the previous picture. In such a case the porous bed has become clogged with impervious matter, so that when the water reaches this point it cannot flow farther. The bed of porous rock is thus full of water, which rises in a bore

HOW SNOW BEGINS TO MELT IN THE SUN

After the snow has fallen it lies as a glistening carpet upon the ground, but as soon as the Sun shines upon it it begins to melt. You will have noticed, however, that it does not melt evenly all over the surface. As we see in the photograph, it becomes pitted, and the pits get larger and larger as the snow melts, till at last they join, and eventually the snow has all been transformed into water. The reason that the snow thaws in this uneven way is that when it falls some of the flakes project above the others, and these melt first. Then when they have changed into water, the warmth of the water begins to melt the other flakes round about, and so in this way the pits are formed and become larger and larger. The greater the quantity of water already melted, the greater is the warmth to carry on the work. Snow, of course, takes up much more room than water, but the number of inches of snow corresponding to an inch of water varies a good deal. Sometimes six inches of snow when melted will make an inch of water, while at other times it takes thirty inches of snow to do the same. It all depends on the lightness of the snow. The average, however, is about ten inches of snow to one inch of water. As there is no variation in the texture of rain, an inch of rain is always the same quantity.

THE MEANING OF BUCHAN'S COLD AND WARM SPELLS

We often read or hear about Buchan's Cold Spells and Buchan's Warm Spells, and many of us know that these have something to do with the weather. But exactly what are these spells ?

Well, they are named after Alexander Buchan, a Scottish meteorologist born in 1829. He was the youngest son of a weaver, and while still a boy took a great interest in scientific subjects, particularly botany. He went to Edinburgh University, where he took a degree and then became a schoolmaster. But he had a weak throat, and this soon compelled him to give up teaching.

Then he was appointed secretary of the Scottish Meteorological Society, and from that time devoted his life to the study of weather science.

Part of his work was to compile weather statistics based on the observations of people in different parts of the country, and after he had been doing this for many years he came to the conclusion that periods of the same kind of weather occur again and again at about the same time of year.

For example, he said that from April 11 to 14 is a period when we usually get cold weather, and a further marked period of cold occurs in the middle of May.

Buchan declared that there are six cold and three warm periods, as follows :

First cold period ....February 7 to 10
Second cold period...April 11 to 14
Third cold period....May 9 to 14
Fourth cold period...June 29 to July 4
First warm period...July 12 to 15
Fifth cold period....August 6 to 11
Second warm period..August 12 to 15
Sixth cold period....November 6 to 12
Third warm period...December 3 to 9

It is interesting to test Buchan's statement for ourselves, and it will certainly be found that very often he is correct within a few days.

Much misunderstanding of the meaning of Buchan's spells has arisen. Buchan's observations were concerned with a small area of Scotland, not meant to apply to the British Isles generally; nor did he suggest that a cold or warm spell might be expected on the dates given in any particular year, but that over a long time there would be an irregularity of a fraction of a degree compared with the seasonal normal. It happens that some periods are also known to tradition or confirmed by statistics in Europe.

Meteorology as a science is in its infancy, and while we may recognize the repetition of certain cold and warm periods in different years, we are unable at present to say why these recur.

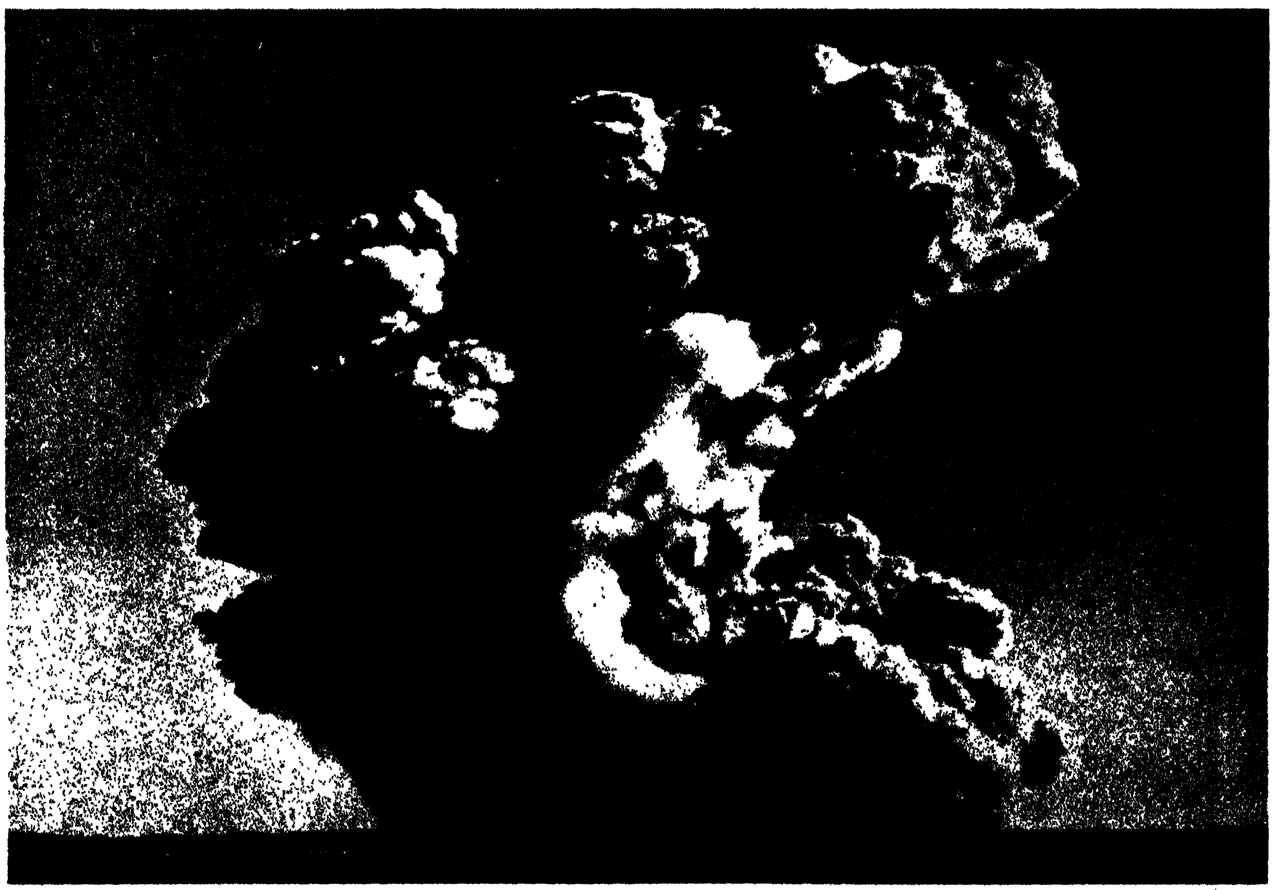
Nowadays it is realised that if the weather is to be properly studied there must be regular examination of the upper atmosphere, and how this is done by radio balloons is explained in page 1026 of this book.

LOOKING DOWN ON THE TOP OF THE WORLD

This " Times " photograph shows us the very top of Mount Everest, the highest mountain in the world. It was taken on April 3, 1933, during the flight over the top of the mountain by the members of the Houston-Everest Expedition and gives a vivid impression of the awe-inspiring summit of the mountain as seen from the north-west. It is solemn to think, as we look down on this mighty peak, that somewhere near the top lie the frozen bodies of two very gallant Englishmen, A. C. Irvine and G. L. Mallory, who in the 1924 expedition to climb Everest left the last camp and set out for the top, but never came back. Mount Everest was first climbed on May 29, 1953, when the New Zealander Edmund Hillary and the Sherpa guide Nockay Tensing reached the summit, as shown in page 317.

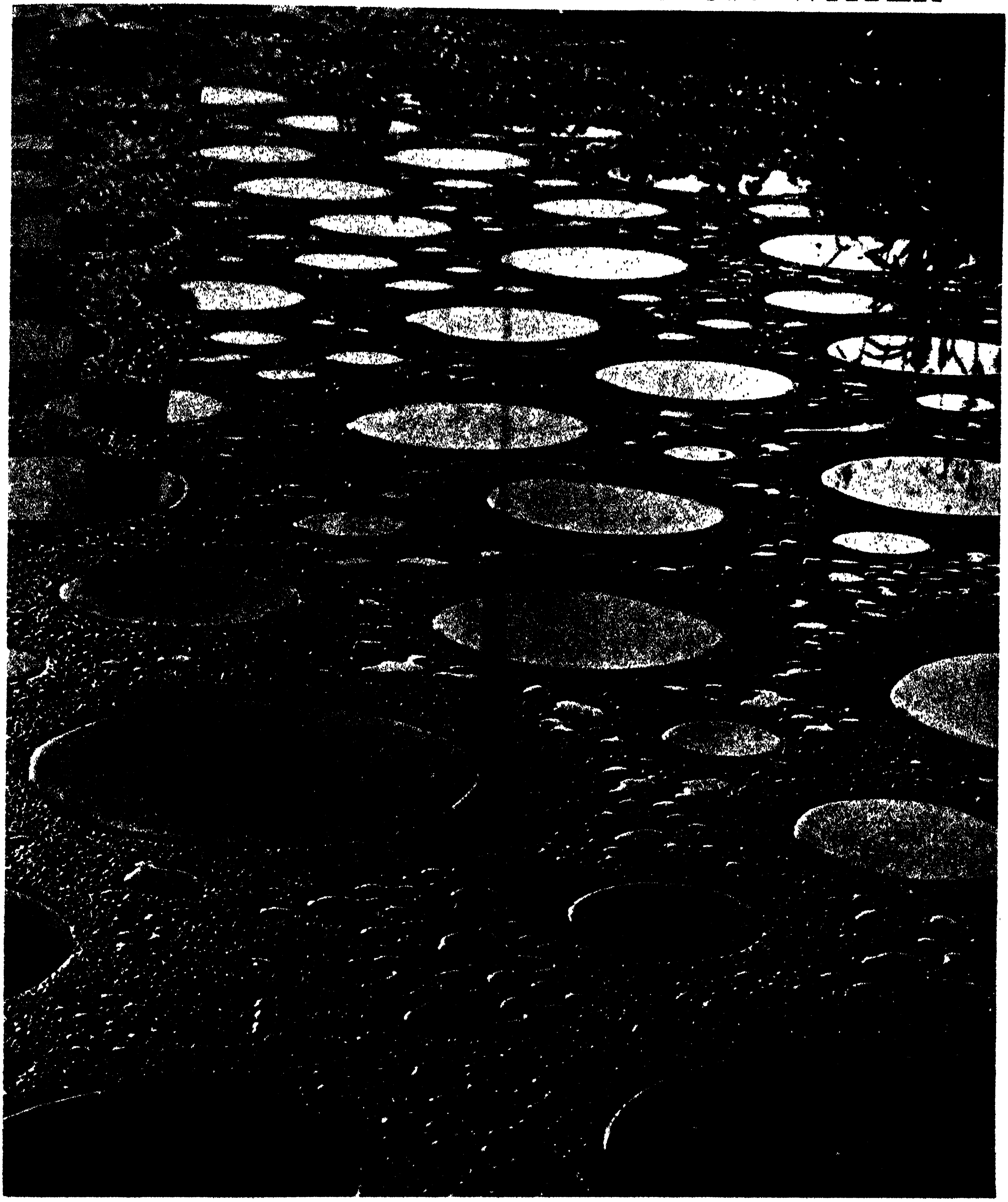
WHEN AN ATOMIC BOMB EXPLODES

This photograph, taken by an automatic camera on the island of Bikini in the Pacific, shows the explosion of an atomic bomb detonated underwater in the midst of a fleet of unmanned ships on July 24, 1946. The mushroom shape was caused by a column of water and spray thrown up by the explosion. The bomb was made in the U.S.A.



On October 3, 1952, the first British atomic bomb was detonated off the Montebello Islands, 50 miles north-west of Australia. The photograph, taken a few minutes after the explosion, shows the smoke cloud two miles high and a mile wide. Its twisted shape is due to the different directions of the wind at different heights

WHY OIL ALWAYS FLOATS ON WATER

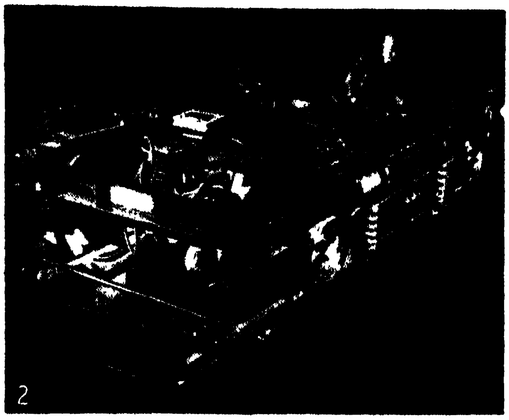


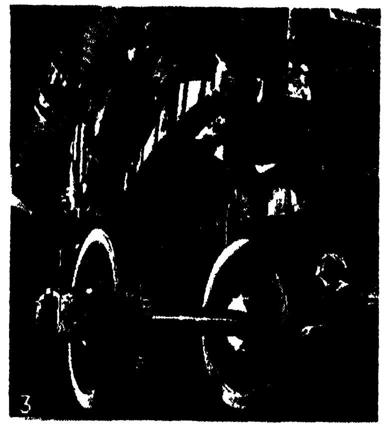
Why is it that oil floats on water? If we pour ink on water it does not float, but mixes with the water. Oil, on the other hand, as shown in this remarkable photograph, spreads itself out and floats on the surface There are two things that decide whether a substance shall float on the surface of water or not. One is whether the substance is soluble, and the other whether it is lighter than an equal volume of water. A piece of sugar placed in water sinks because it is heavier than an equal bulk of water, and it dissolves because it is soluble in water. A cork will float because it is lighter than an equal bulk of water, and is insoluble. Now when we place oil on the surface of water it floats because it is lighter than an equal bulk of water and will not dissolve in water. It spreads out to form a thin film because the tension of its surface is weak compared with that of water. In other words, the cohesion holding the molecules of oil together is overcome by other forces. If olive oil be introduced into a mixture of water and alcohol, having the same density as the oil, the oil forms in globules and rests in any part of the mixture in which it may be placed, not merely on top

Of recent years the picturesque and romantic steam locomotive which since the days of George Stephenson had been the prime mover of the world's passenger and freight traffic by land has been giving way to diesel and electric power. In 1955 the British Transport Executive began a programme of railway modernisation which, when it is completed in 1970, will mean the disappearance of the steam engine from all tracks in the United Kingdom. All haulage by rail will be by either electric or diesel-electric locomotives. Electric traction means either the erection of overhead lines or the laying of third rails to carry the current supplying the locomotive's electric motors. This entails a very heavy capital expenditure; to avoid that and at the same time utilise existing tracks the diesel-electric locomotive will be used where conditions are suitable. With a diesel-electric locomotive, a diesel engine is used to drive a generator that produces current to supply electric motors which turn the locomotive's rail wheels. By this method, the diesel-electric locomotive is a completely self-contained power unit and is independent of any breakdown at a power station. Where direct electric power is used for locomotives, a power failure at the generating station brings all electric trains over a wide area to a standstill. Several main lines on the British Railways system have already adopted diesel-electric locomotives of the type illustrated on this and the opposite pages.

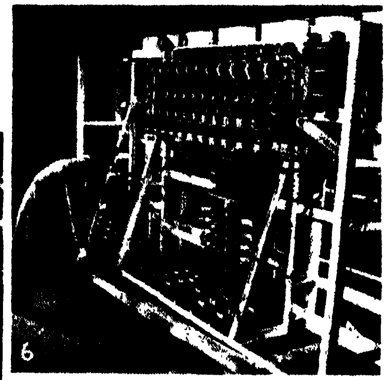
The photograph on the left shows a diesel-electric locomotive used on the Southern Region of British Railways. The drawing above is of the same locomotive cut away and lettered to indicate its chief parts: A, driving cab; B, radiator; C, fuel tank; D, diesel engine; E, main traction generator; F, auxiliary generator; G, water tank; H, electrical equipment; J, air compressor; K, traction motors; L, driving wheels; M, sanding pipes; N, mechanical lubricator. The locomotive weighs 135 tons, is 65 feet nine inches long, and is powered by a diesel engine of 1,750 horse-power. The diesel engine, the generator, and the electric motor were built by the English Electric Company. The photographs on the opposite page show the building of a similar locomotive at the same company's works.

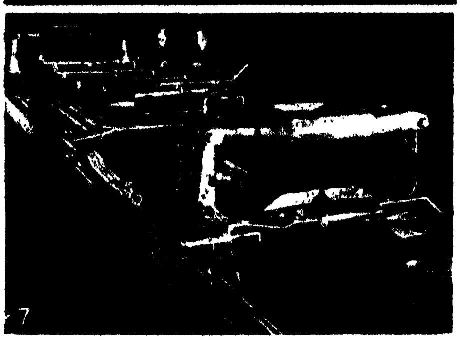
HOW A DIESEL-ELECTRIC LOCOMOTIVE IS BUILT





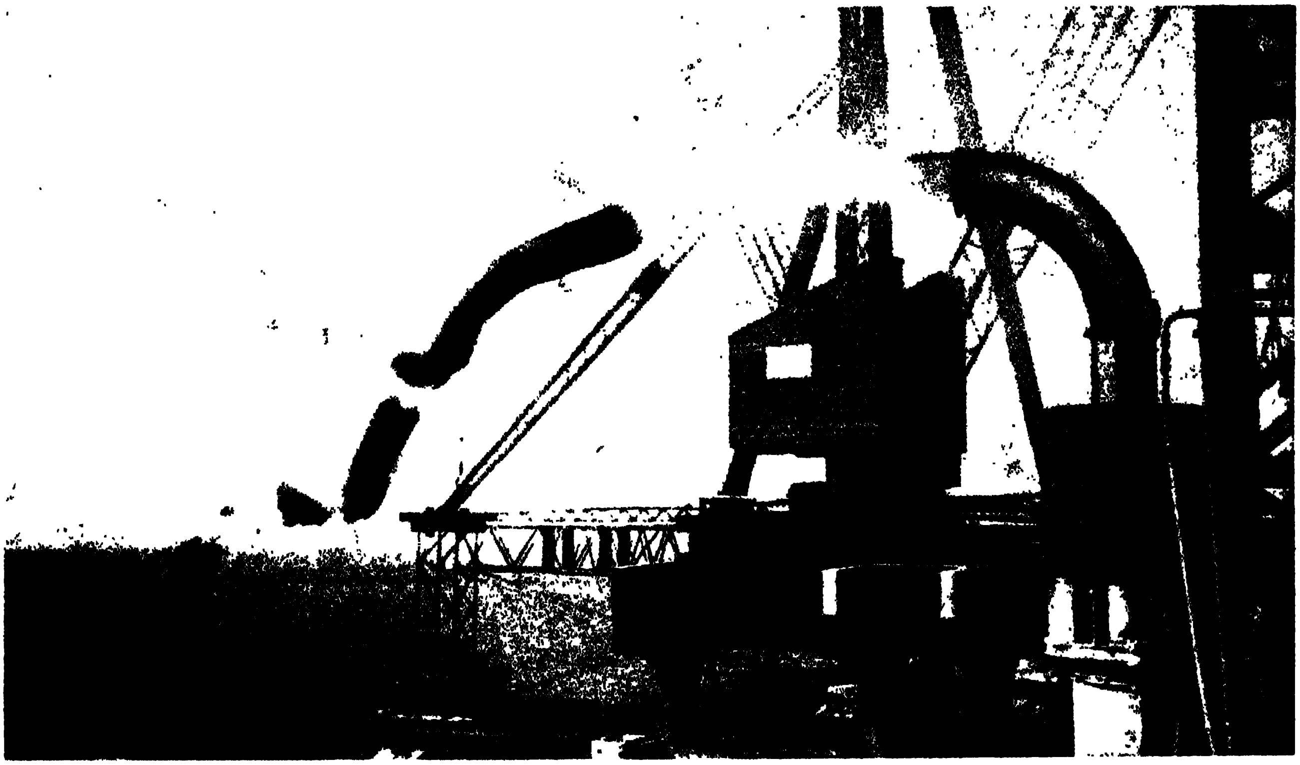
These photographs, taken in the works of the English Electric Company, illustrate various stages in the building of a locomotive of the type shown on the opposite page. 1, Fitting the armature of the electric motor driving the locomotive wheels ; 2, One of the locomotive's bogies with the motor in position;



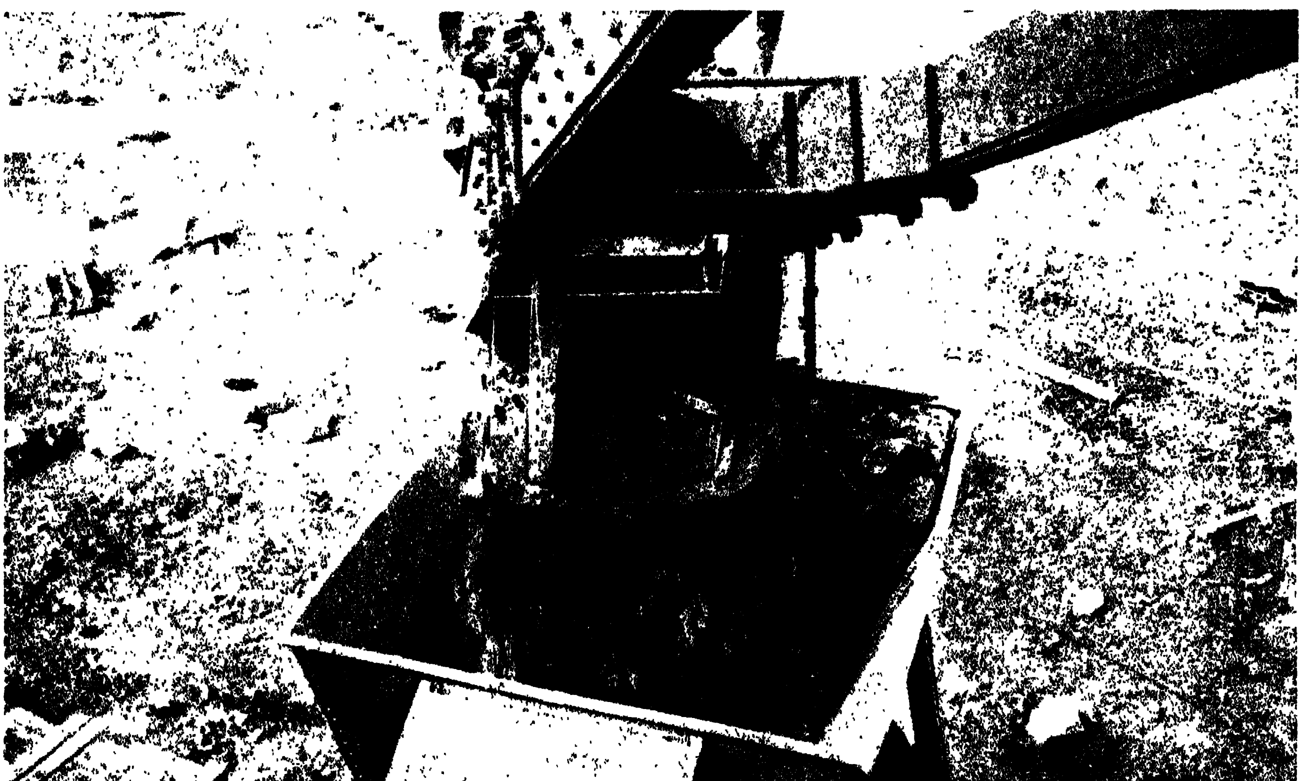


3. Lowering a bogie on to its wheels ; 4, Testing an axle to ensure that it is straight and true ; 5, Assembling the driver's controls ; 6, Bank of resistances that control motor speed ; 7, Building main locomotive frame ; 8, Testing armature components of motor ; 9, Locomotive with skeleton for coachwork ; 10, Locomotive skeleton partly covered with steel panelling ; 11, Locomotive finished and ready for delivery.

TWO MODERN METHODS OF EXCAVATING



In building large bridges caissons, or huge hollow cylinders, are usually sunk in the river and then men go down and work in compressed air digging out the river bed for the foundations of the bridge. It is dangerous work, and the men often contract a complaint known as caisson disease due to the great air pressure. By a new system shown here, instead of the river bed being dug out, the material is blown out as a series of clay sausages by compressed air pumped down at a pressure of 120 pounds to the square inch



More and more excavating work is done by means of marvellous machinery that saves the labour of scores of men. In the Stewartby brick works near Bedford, said to be the largest in the world, this electrically driven excavator is used for digging out the clay. It scoops up over eight tons at a time from the clay bed and enables bricks to be made speedily in enormous quantities

THE BLACK HOLE OF CALCUTTA

Everyone has heard of the Black Hole of Calcutta, but the story itself is not so well known as it should be. In these pages is given the narrative of this dramatic episode in Anglo-Indian history. It has been said that the Black Hole of Calcutta marked the beginning of English domination in India

THE first Englishmen to go to India went not to rule but to trade with the natives. It was in 1591 that three ships set out for the East, but only one of them reached India, and three years later its commander arrived home in another ship, the sailors having seized his own vessel. The story he told about India and the possibilities of trade there led to the establishment of an English East India Company, and a charter permitting it to trade was granted by Queen Elizabeth on the last day of the 16th century.

The name East India was given to the Company to distinguish it from the West Indies, for when the American islands were discovered they were supposed to be a part of India, and were called the West Indies as distinct from that part of India which was reached by the Eastern route and was consequently called the East Indies. When the mistake was discovered the old terms were still retained.

Trade Before Empire

At first the East India Company was not very ambitious. It formed some little settlements on different parts of the coast of India, and there the merchants lived and traded, paying rent to the natives for the ground they used. At each settlement a little fort was built, and a few soldiers were kept for protection, but those early Englishmen in India never thought of possessing or ruling the country; their one idea was to trade and grow rich.

The chief settlement was at Madras. Not far south at Pondicherry the French established a station, and there was great rivalry between the two nations even in peace time. When the two countries at home were at war then the settlements in India were soon at war, too.

By the end of the 17th century the East India Company held three posts in India—Fort St. George at Madras, Bombay, which Charles the Second had received from Portugal as a marriage portion with his wife, Catharine of Braganza, and had made over to the Company, and finally Fort William on the River Hoogly in Bengal, round which, later on, grew up the great city of Calcutta. This latter piece of ground the East India Company had acquired from the Great Mogul who ruled at Delhi, but later the Mogul's empire began to break up, and his Subahdars or Viceroys in different areas became practically independent. The English and the French traders used to make friends of the Viceroys, and their Nawabs or district governors, and would play off one against the other in their trade rivalry. Often the terms Subahdar and Nawab were used indiscriminately, one title or the other being largely a matter of opinion or taste.

The notorious "Black Hole," a small apartment 18 feet by 14 feet with only two small windows, where 145 Englishmen and one woman were imprisoned

In 1756, when the old Nawab of Murshidabad died, there were rival claimants to his throne, but the power was seized by a grandson of the old Nawab named Suraja Dowlah. He was an insolent, vindictive, and cruel young man, and for some reason was very hostile to the English. When, therefore, he heard that Calcutta was being strongly fortified against possible French attack, and that one of his own enemies had found refuge there, he demanded the immediate surrender of the place.

No reply was sent, and thereupon the Nawab ordered Mr. Drake, the Governor of Calcutta, to demolish the new fortifications. Mr. Drake replied that there were no new fortifications, and that beyond repairing a line of guns nothing had been done.

Suraja Dowlah thereupon assembled an army of 50,000 men with a body of artillery, and marched to Calcutta. He captured a factory in the suburbs, and the English, who had really neglected their defences, were staggered by this turn of events. There were not 500 men in the whole of Calcutta, including both Englishmen and mixed races, and of these only 170 were European soldiers, of whom not more than ten had ever seen active service. What was to be done?

A few feeble efforts were made to defend the town, but when the Nawab's forces drove the English back upon the fort Mr. Drake determined that the women should go aboard the ships lying in the river, and he and a few of his friends took care to escape with them.

A Gallant Defence

Then, to the great disgust of those in the fort, he ordered the ships to sail away. It was a dastardly trick to run away and leave his fellow-countrymen to the mercy of the Nawab. If all the men had remained and defended the place energetically, it could probably have been saved. Even as it was, a gallant attempt was made to resist the Nawab.

Mr. John Holwell, a civilian, was by common consent placed in command, and for forty-eight hours the fort held out. When it was found that the defenders were too few to hold out for long, signals of distress were made to the vessels anchored below the town. These could easily have come up and rescued the gallant garrison, but not a vessel moved to its assistance.

At last, when more than half his small force had been killed or wounded, Mr. Holwell saw a flag of truce coming from the Nawab's army. He agreed to a parley, during which the enemy treacherously rushed into the fort, and all were obliged to surrender. Mr. Holwell was ushered into the Nawab's presence, and that ruler expressed his

anger that only five lacs of rupees, or £50,000 had been found in the Treasury. However, he gave his assurance that the garrison should be protected, and then retired at dusk to his encampment.

The European prisoners were gathered under an arched veranda while native officers went in search of some place where they could be kept safely for the night. These men returned to say that no suitable place could be found and the native officer in charge of the prisoners then ordered them to move into one of the chambers behind the veranda which had been used as a lock-up for disorderly soldiers, and was known as the Black Hole.

It was 18 feet long by 14 feet wide, had only two little windows, but no proper ventilation, and the door opened inwards. Into this tiny compartment the whole of the prisoners, consisting of 145 men and one woman, were driven, and the door was then shut There the unfortunate people were kept in the stifling climate of Bengal for the whole of the night, with the inevitable result that most of them were suffocated.

The Resolution to Rule

The news of this tragedy did more than anything else to steel the hearts of the English, and make them determined that henceforth they would not be at the mercy of the native Indian rulers, but would themselves gain power and rule and make India safe for Englishmen. We may almost say that the Black Hole of Calcutta was the very beginning of English domination in India.

The story of that dreadful night has been told in graphic words by Mr. Holwell himself, and those who wish to know the truth about the Black Hole of Calcutta cannot do better than read his own story.

The Subah, or Viceroy of Bengal, and his troops (says Mr. Holwell) were in full possession of the Fort before six o'clock in the evening. At an interview with him about 7 o'clock, he repeated his assurances to me, on the word of a soldier, that no harm should come to us.

Indeed, I believe his orders, at least, at first, were only general; that we should be "safely secured for the night"; and that what actually followed was, in a great measure, the result of revenge and resentment of the jemidars or native officers, to whose cruelty we were delivered.

Be this as it may, as soon as it was dark we were all, without distinction of rank, position, age or sex, directed by the guard set over us to collect ourselves into one body and sit down under the arched veranda or piazza to the west of the Black Hole Prison. Just as it became dark a large number of soldiers, who had been drawn up on the parade, advanced and made us all rise and go into the barracks, to the left of the Court of Guard.

We were no sooner all within them than the guard advanced to the inner arches and parapet wall, and, with their muskets presented, ordered us to go into the room at the southernmost end of the barracks, commonly called the Black Hole Prison.

Among the first to enter were myself, Messrs. Baillie, Jenks, Cooke, T. Coles, Ensigns Scott, Revely, Law and Buchanan. I got possession of the window nearest the door, and Messrs Coles and Scott got into the window with me, they being both badly wounded, the first I believe mortally The rest of the above-named gentlemen were all close round me.

A flag of truce was seen coming from the Nawab's army

It was now 8 o'clock. Figure to yourself, if possible, the dreadful situation of a hundred and forty-six wretches, exhausted by continual fatigue and action, crammed all together in a cube of eighteen feet on a hot night in Bengal; shut up from the East and South--the only points from whence air could reach us--by dead walls; and by a wall and door on the North, and open only to westward by two windows strongly barred with iron, from which we could receive scarce any circulation of fresh air.

What must ensue appeared to me in lively and dreadful colours the instant I cast my eyes around and saw the size and situation of the room. Many unsuccessful attempts were made to force the door, for having only our hands to work with and the door opening inward, all our endeavours were vain and fruitless.

Amongst the guards posted at the window I observed an old jemidar near me, who seemed to carry some compassion for us in his countenance. I called him to me and pressed him to endeavour to get us separated, half in one place and half in another, and said that he should, in the morning, receive a thousand rupees for this act of kindness

He withdrew, but in a few minutes returned and told me it was impossible.

We had been here but a few minutes, before every one fell into a perspiration so profuse you can form no idea of it. This brought on a raging thirst, which increased in proportion as the body was drained of its moisture.

Various expedients were thought of to give more room and air To obtain the former, it was moved to put off our clothes. This was approved as a happy notion, and in a few minutes I believe every man was stripped, myself, Mr. Court, and the two young gentlemen by me, excepted. For a little time they flattered themselves with having gained a mighty advantage.

Pitiful Efforts

Every hat was set in motion to produce a circulation of air, and Mr. Baillie proposed that every man should sit down on his hams. This expedient was several times put in practice, and at each time, many of the poor creatures whose natural strength was less than that of others, or who had been more exhausted, and could not recover their legs as others did when the word was given to rise, fell to rise no more. They were instantly trodden to death or suffocated.

Before nine o'clock every man's thirst grew intolerable, and respiration was difficult. Efforts were again made to force the door, but in vain. Many insults were used to the guards to provoke them to fire in upon us. For my own part, I hitherto felt little pain or uneasiness but what resulted from my anxiety for the sufferings of the others.

By keeping my face between two of the bars I obtained air enough to give my lungs easy play, though my perspiration was excessive and thirst tormenting. At this period, so strong an effluvia came from the prison, that I was not able to turn my head that way for more than a few seconds at a time.

Now, everybody, excepting those situated near the windows, began to be outrageous, and many delirious. "Water! Water!" became the general cry; and the old jemidar before mentioned, taking pity on us, ordered the people to bring some skins of water. This was what I dreaded. I foresaw it would prove the ruin of the small chance left us, and essayed many times to speak to

him privately to forbid its being brought. The noise and clamour was, however, so loud, it became impossible.

The water appeared. Words cannot paint to you the universal agitation and raving the sight of it threw us into. I flattered myself that some, by preserving an equal temper of mind, might outlive the night; but now, the reflection which gave the greatest pain was, that I saw no possibility of any escaping to tell the dismal tale.

Until the water came I, myself, had not suffered so much from thirst, which instantly became excessive. We had no means of conveying it into the prison but by hats forced through the bars; and thus, myself, and Messrs. Coles and Scott, notwithstanding the pains they suffered from their wounds, supplied them as fast as possible.

Though we brought full hats within the bars, there ensued such violent struggles and contests to get at it, that before it reached the lips of any one, there would be scarcely a small teacupful left in it. These supplies, like sprinkling water on fire, only served to feed and raise the flame. How shall I give a conception of what I felt at the cries and ravings of those in the remoter parts of the prison, who could not entertain a hope of obtaining a drop, yet could not divest themselves of expectation, however unavailing, and calling on me by the tender considerations of friendship and affection, and who knew that they were really dear to me!

Horrible Confusion

The confusion now became general and horrid. Several quitted the other window—the only chance they had for life—to force their way to the water, and the throng and press upon our window was fearful and almost beyond bearing. Many, forcing their passage from farther parts of the room, pressed down those in their way who had less strength, and trampled them to death.

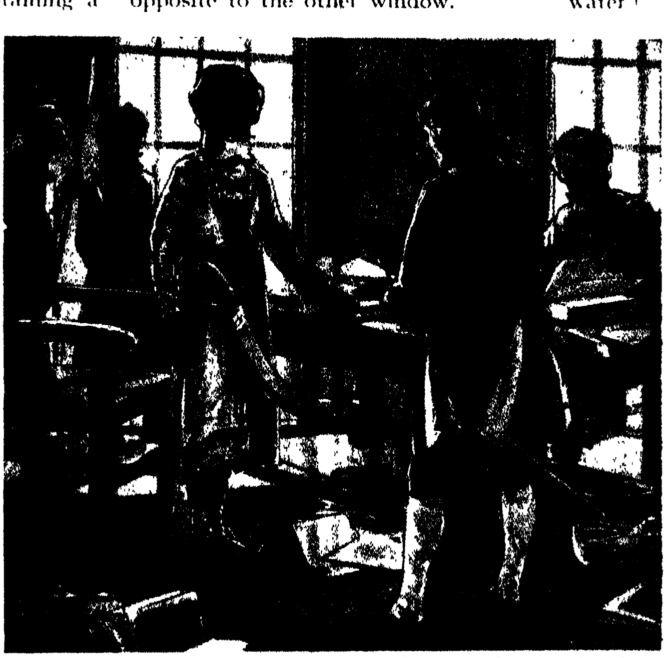
From about nine to eleven I sustained this cruel scene and painful situation: still supplying them with water, though my legs were almost broke with the weight brought against them. By this time I was myself nearly pressed to death, and my two companions, with Mr. William Parker, who had forced himself into the window, were really so.

For a great while, they all preserved a respect and regard for me, more than, indeed, I could well expect, our circumstances being considered; but now, all distinction was lost. My friend Baillie, Messrs. Jenks, Revelly, Law, Buchanan, Simpson, and several others, for whom I had a real esteem and affection, had been lying dead at my feet, and they were now trampled upon by every corporal and common soldier, who, by the help of their more robust constitutions, had forced their way to the window, and held fast by the bars over me: till at last I became so pressed and wedged up, that I was deprived of all motion.

Giving Up the Struggle.

Determined now to give up everything, I called to them, and begged, as the last instance of their regard, that they would remove the pressure upon me, and permit me to retire out of the window to die in quiet. They gave way, and with much difficulty I forced a passage into the centre of the prison, where the throng was less, through the many dead, then amounting to one-third, and the number who flocked to the windows, for by this time they had water at the other window.

In the Black Hole there is a platform raised between three or four feet from the floor, open underneath, and extending the whole length of the east side of the prison. It was six feet wide, corresponding with that in the barrack. I travelled over the dead bodies, and repaired to the farther end of it, just opposite to the other window.



The Nawab expressed his anger that only five lacs of rupees had been found in the Treasury

Here my poor friend Mr. Edward Eyre came staggering over the dead to me; and, with his usual coolness and good nature, asked me how I did. He fell and expired before I had time to make him a reply. I laid myself down on some of the dead behind me on the platform; and, commending myself to Heaven, had the comfort of thinking my sufferings could have no long duration.

My thirst grew now unsupportable, while the difficulty of breathing much increased. I had not remained in this situation, I believe, ten minutes, when I was seized with a pain in my breast, and palpitation of the heart, both to the most exquisite degree. These roused and obliged me to get up again; but still the pain, palpitation, thirst, and difficulty of breathing increased. I retained my senses notwithstanding, and had the grief to see death not so near me as I had hoped.

But I could no longer bear the pain I suffered, without attempting a relief, which I knew fresh air would and could only give me. I instantly determined to push for the window opposite to me and, by an effort of double the strength I had ever before possessed, I gained the third rank at it, with one hand seized a bar, and by that means gained the second, though I think there were at least six or seven ranks between me and the window.

In a few moments the pain, palpitation and difficulty of breathing ceased, but my thirst continued intolerable. I called for water, "For God's sake!" I had been concluded dead, but as soon as they found me amongst them again, they still had the respect and tenderness for me to cry out: "Give him water, give him water!" Nor would one of them at the window attempt to touch it till I had drunk.

But from the water I had no relief; my thirst was rather increased by it. So I determined to drink no more; but patiently wait the event; and kept my mouth moist, from time to time, by sucking the perspiration out of my shirt-sleeves, and catching the drops as they fell, like heavy rain, from my head and face. You can hardly imagine how unhappy I was if any of them escaped my mouth.

The Tortures of Thirst

I came into the prison without coat or waistcoat. The season was too hot to bear the former, and the latter tempted the avarice of one of the guards, who robbed me of it, when we were under the veranda.

Whilst I was at the second window I was observed by one of my miserable companions, on the right of me, in the expedient of allaying my thirst by sucking my shirtsleeve. He took the hint and robbed me, from time to time, of a considerable part of my precious store, though, after I detected him, I had the address to begin on that sleeve first, when I thought my reservoirs were sufficiently replenished and our mouths and noses often met in the contest.

This plunderer, I found afterwards, was a young gentleman in the Service, Mr. Lushington, one of the few who

escaped from death, and he has since paid me the compliment of assuring me that he believed he owed his life to the many comfortable draughts he had had from my sleeves.

By half-past eleven the much greater part of those living were in an outrageous delirium, and the others quite ungovernable—few retaining any calmness but the ranks next the windows. They all now found that water, instead of relieving, rather heightened their uneasiness, and "Air, air!" was the general cry

Every insult that could be devised against the guard, all the opprobrious names and abuse the Subah and others could be loaded with were repeated to provoke the soldiers to fire upon us. Every man that could rushed tumultuously to the window, with eager hopes of meeting the first shot. Then a general prayer to Heaven to put an end to our fearful misery.

But these failing, they whose strength and spirits were quite exhausted laid themselves down and expired quietly on their fellows. Others who had yet some little strength and vigour left made a last desperate effort for the windows. Several succeeded by leaping and scrambling over the backs and heads of those in the first ranks, and got hold of the bars, from which there was no removing them. Many to the right and left sank with the violent pressure and were soon suffocated

A Terrible Ordeal

I need not ask your commiseration when I tell you that, in this plight, from half-past eleven till near two in the morning I sustained the weight of a heavy man with his knees on my back and the pressure of his whole body on my head, a Dutch sergeant who had taken his seat on my left shoulder, and a Topaz, a black Christian soldier, bearing on my right, all of which nothing could have borne me to support, but the props and pressure equally sustaining me all around.

The two latter I frequently dislodged by shifting my hold on the bars and driving my knuckles into their ribs; but my friend above stuck fast and, as he held by two bars, was immovable. The repeated trials and efforts I made to dislodge this insufferable incumbrance upon me at last quite exhausted me, and towards two o'clock, finding I must quit the window or sink where I was, I resolved on the former, having borne, for the sake of others, infinitely more for life than the best of it is worth.

In the rank close behind me was an officer of one of the ships whose name was Carey, and who behaved with much bravery during the siege. His wife, a fine woman, though country-born or half-caste, would not quit him, but accompanied him to the prison, and was one of the few who survived. This poor wretch had been long raving for water and air I told him I was determined to give up life, and recommended his gaining my station. On my quitting, he made an attempt to get my place, but was supplanted.

Poor Carey expressed his thankfulness, but said he would give up life, too. But it was with the utmost labour that we forced our way from the window, several in the inner ranks appearing to me to be dead, standing. He laid himself down to die, and his death, I believe, was very sudden; for he was a short, full, sanguine man. His strength was great, and I imagine, had he not retired with me, I should never have been able to have forced my way

Words cannot paint the universal agitation and raving the sight of the water threw the prisoners into

I was at this time sensible of no pain and little uneasiness. I found a stupor coming on apace, and laid myself down by that gallant old man, the Rev. Mr. Jervas Bellamy, who lay dead, with his son, the lieutenant, hand-in-hand near the southernmost wall of the prison.

When I had lain there some little time, I still had reflection enough to suffer some uneasiness in the thought that I should be trampled upon when dead, as I had myself done to others. With some difficulty, I raised myself and gained the platform a second time, where I presently lost all sensation. The last trace of sensibility that I have been able to recollect after my lying down was my sash being uneasy about my waist, which I untied and threw from me. Of what passed in this interval to the time of my resurrection from his hole of horrors I can give you no account.

When the day broke, and the gentlemen found that no entreaties could prevail to get the door opened, it occurred to one of them—I think Mr. Secretary Cooke—to make a search for me, in hopes I might have influence enough to gain a release from this scene of misery. Accordingly, Messrs. Lushington and Walcot undertook the search and, by my shirt, discovered me under the dead upon the platform. They took me from thence and, imagining I had some signs of life, brought me towards the window I had first possession of.

But, as life was equally dear to every man, no one would give up his station in or near the window; so they were obliged to carry me back again! But soon after, Captain Mills, now commanding the company's yacht, who was in possession of a seat in the window, had the humanity to resign it. I was again brought by the same gentlemen and placed in the window

Release at Last

At this juncture the Subah, who had received an account of the havoc death had made amongst us, sent one of his jemidars to inquire if the chief survived. They showed me to him, told him I had the appearance of life remaining, and believed I might recover if the door was opened very soon.

This answer being returned an order came immediately for our release, it being then near six o'clock in the morning As the door opened inwards, and as the dead were piled up against it and covered all the rest of the floor, it was impossible to open it by any efforts from without. It was therefore necessary that the dead should be removed by the few that were within who were become so feeble that the task, though it was the condition of life, was not performed without the utmost difficulty, and it was twenty minutes after the order came before the door could be opened.

About a quarter-past six in the morning the poor remains of one hundred and forty-six souls, being no more than three-and-twenty, came out of the Black Hole alive, but in a condition which made it very doubtful whether they would see the morning of the next day! Among the living was Mrs. Carey; but poor Leech was among the dead. The bodies were dragged out of the Hole by the soldiers and thrown promiscuously into the ditch of an unfinished ravelin, which was afterwards filled with earth.

Soon afterwards Suraja Dowlah released Mr. Holwell and the other prisoners, and a year later his cruelty was avenged by Robert Clive, founder of the English Empire in the East.

THE ROMANCE OF A GRAIN OF WHEAT

Wheat, like all our cereal plants, has been developed from a wild grass, but it has been improved out of all recognition. At the present time there are said to be over a thousand varieties of wheat that are grown for food, and although a quarter of a century ago Sir William Crookes warned the world that the wheat crop would soon be insufficient for the needs of mankind, to-day more wheat is grown than can be sold. Here we read the wonderful story of this valuable food plant

WHEAT is the most important food in the world, and those nations which have been wheat-eaters have built up the most powerful empires, and, speaking generally, have subdued the peoples which lived principally on other forms of food.

For example, the wheat-eating English became masters of the rice-eating Indians, and the wheat-eating Spanish and Portuguese conquered the bean- and maize-eating people of the New World. It is a curious fact that the Japanese, since they made themselves one of the great powers of the world, have been slowly changing from a rice-eating to a wheat-eating people.

Now wheat, like the other cereals, such as oats, barley, rye and rice, is really a grass, and there is no doubt whatever that of all the different kinds of plants in the world the grass family is the most important. It provides the chief food not only of human beings but of the animals also. Our horses and cattle and sheep and poultry are fed on the grasses that grow in the meadows, and on oats, barley and maize or Indian corn.

Great Advantages of Wheat

Wheat is the best of all food plants. It contains more nitrogen than other cereals like rice and maize, and it has the great advantage that a sticky substance known as gluten, of which it contains a large amount, enables it to be made into a light and appetising bread which is very digestible. Oatmeal cannot be made into dough like wheatmeal.

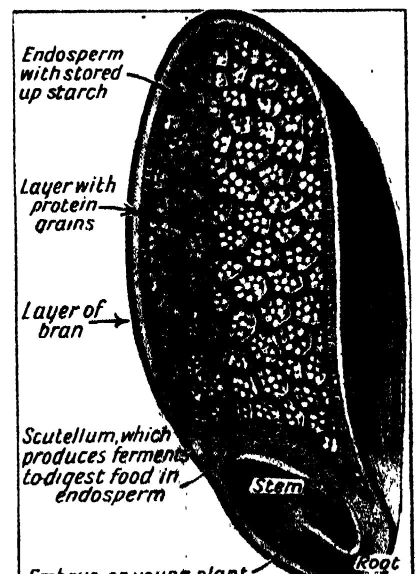
Another great advantage of wheat is that it is a wonderfully adaptable plant and with a thousand varieties produced by man in recent years suited to different soils and circumstances, it can now be grown in almost any kind of earth and in almost any temperate climate.

The Wheat Belt, that is, the area in which wheat can be grown and ripened profitably, is constantly being extended, and vast crops of wheat are now harvested in Canada hundreds of miles farther north than was the case not very many years ago.

As already explained, wheat is a grass, and of course the first wheat that man used was gathered from wild plants. Other cereals have also been developed from wild plants, and we know that wild oats and wild barley still grow in England.

But for a long time, although they searched, men of science could not find wild wheat growing. Then one of them found, on looking through the pressed specimens of grasses in the National Museum at Vienna, on a sheet of wild barley, a plant which at once attracted his eye. He recognised it as a species of wild wheat. He reported his find to the world in 1880, explaining that this specimen had been gathered on Mount Hermon in Palestine in 1855.

At once scientists began to search on Mount Hermon to find wild wheat growing, and special expeditions were sent for the purpose. But it was only in 1906 that a Jewish scientist actually



A grain of wheat does not look very interesting, but if we magnify it we can see that it is made up of various parts, as shown here. It is because of its large store of protein that wheat is such a valuable food for mankind. The plant stores up the proteins in its seed not, of course, for mankind but to feed the young plant when the seed has started to germinate

found the wild wheat growing in a rocky crevice on the mountain. This was one of the most interesting scientific discoveries that had been made for a very long time, and confirmed the belief that wheat originated in the Mediterranean countries.

That it has been used for food for thousands of years we know from the fact that wheat grains have been found in the rubbish heaps of the lake dwellings of Switzerland and Italy. Prehistoric man cultivated wheat long before history came to be written, and we also know that the old civilisations of Babylon, Egypt, Crete, Greece and Rome were all based on wheat as one of the chief food plants.

Who first found that wheat was good for food? No one can say. Probably it was some Stone Age woman in the days when mankind lived only upon animals caught in the chase. Perhaps her menfolk had been killed, or perhaps there had been difficulty in getting any animal food, and this woman may have been so hungry that she tried some of the wild plants that grew all round.

The poor grains of wild wheat, when chewed up, proved pleasant to the taste and after a quantity had been eaten they satisfied the hunger and strengthened the body. Then this woman, who lived thousands of years ago, probably told her friends, and they harvested the wild grain.

Her little children could not chew up the hard wheat as easily as their grown-up friends, and so the woman decided to grind it up, using two stones for the purpose. There is little doubt that woman was the first miller, and the first baker. In primitive tribes we find the woman is to-day the cultivator of the soil, the miller and the cook.

Woman the First Farmer

But wild wheat was probably not a very prolific plant and having found that it was good for food the next step would be to begin to cultivate it. It is believed that woman was also the first farmer and gardener. She found she could get more wheat by planting the grains, and so she would clear a patch of ground, by removing other plants and digging up the soil with a pointed stick. Thus she produced a crop.

The discovery that food could be grown in this way, that is, the invention of agriculture, was one of the greatest in the history of the world. Without it there could have been no great cities, not even a town of a thousand inhabitants. People would have had to remain spread out over wide areas.

For centuries the quality of the wheat and its yield were poor, but as populations increased by leaps and bounds

GATHERING IN THE HARVEST OF WHEAT

More than a third of the 1,600 million people who make up the world's population at the present time are wheat-eaters, and the proportion is steadily growing. We are not sure where wheat first grew, but some think it was in Palestine and others in Mesopotamia. Whichever may be correct, it is now grown all over the world, except in very hot countries, and huge crops are harvested in Canada, the United States, Argentina and Australia. Here we see a field of wheat being harvested by machinery in Western Australia

In this photograph wheat is being cut and bound by machinery in New South Wales. The improvements in reaping appliances have been as marked as in the machinery of other industries, and were it not for this fact the great wheat crops grown in some countries could never be gathered in time. The men of olden days who used the sickle would be amazed if they could see a harvesting scene such as that shown here. Some harvesting machines now cut the wheat, rake it together, tie it in sheaves and thresh, clean and sack it

STONE AGE WOMAN BEGINS THE WHEAT INDUSTRY

It is generally agreed that it was woman who began the agricultural industry. She was the first farmer and wheat grower. Probably when hungry she tried to satisfy herself by eating grains of wild wheat which she found growing. She spread the news that the food was good, and then she and other women, to make the grains more suitable for the children, pounded them between stones. That was the beginning of milling. Later the flour would be mixed with water to form a cake and would be cooked. Woman thus became a baker, and before long the wheat grains would be sown and the plant grown where it could be conveniently harvested

it became necessary that more and more wheat should be produced How was this to be done?

Well, scientists set to work and, as they have done with so many kinds of fruit, they began creating new varieties of wheat by cross-breeding, that is, by taking the pollen from the stamen or male part of one plant and transferring it to the pistil or female part of another. The results were new kinds of wheat which embodied some of the qualities of both their parents. For example, wheat plants were produced which gave more straw and bore larger heads, with more and larger grains than any that had hitherto been grown. In this way the yield was greatly increased.

Then new kinds of wheat plants were produced which would ripen some days earlier and so could be grown farther north than had been possible before. A remarkable example of this is the Marquis wheat, which in its various forms is the chief variety of wheat grown in Western Canada.

In the latter years of the nineteenth century the principal wheat of Canada was known as Red Fife. It had excellent milling and baking qualities, but unfortunately when the frosts came early Red Fife was often frozen.

A Canadian scientist, Dr. Saunders, and his sons therefore determined to produce a variety of wheat which, while possessing all the good qualities of Red Fife, should mature a little earlier in the season and thus escape the frosts. For this purpose wheats were collected from the colder districts of Northern Russia, from other parts of Northern Europe and Asia, and also from places high up in the Himalayas.

After years of experiment the long-desired wheat was produced, its male parent being Red Fife and the female parent an early-ripening wheat from India known as Hard Red Calcutta. It was in 1903 that a single head bearing a few grains was produced that ripened earlier than usual.

How carefully the grains were harvested and planted in the following spring! Twelve plants resulted and from them was gathered one pound of grain. It was the first crop of a wheat that in a dozen years was to fill the granaries and elevators of Canada and the United States.

That pound of wheat, when planted, gave an excellent yield of very fine wheat, and by 1906 two-thirds of a bushel were available, and in the following year there were 23 pounds of grain. Then samples were sent out to farmers in various parts of the country, and soon the wheat, which was named by its producer Marquis, to indicate its high quality, was grown over hundreds of thousands of acres.

It was taken to the United States, and by 1914 in North America hundreds of millions of bushels of Marquis wheat were harvested. It fulfilled its high promise by ripening early and thus avoiding the frosts.

Another example of how man has improved the wheat is in the production of such varieties as "Little Joss" and "Yeoman," for which we are indebted to Professor Biffen, the Cambridge scientist. The fungus disease of rust, as we read on pages 573 to 575, plays havoc with the wheat crop, and Professor Biffen set himself to produce varieties of wheat which should be immune from rust. He achieved his purpose and saved the farmers millions of pounds.

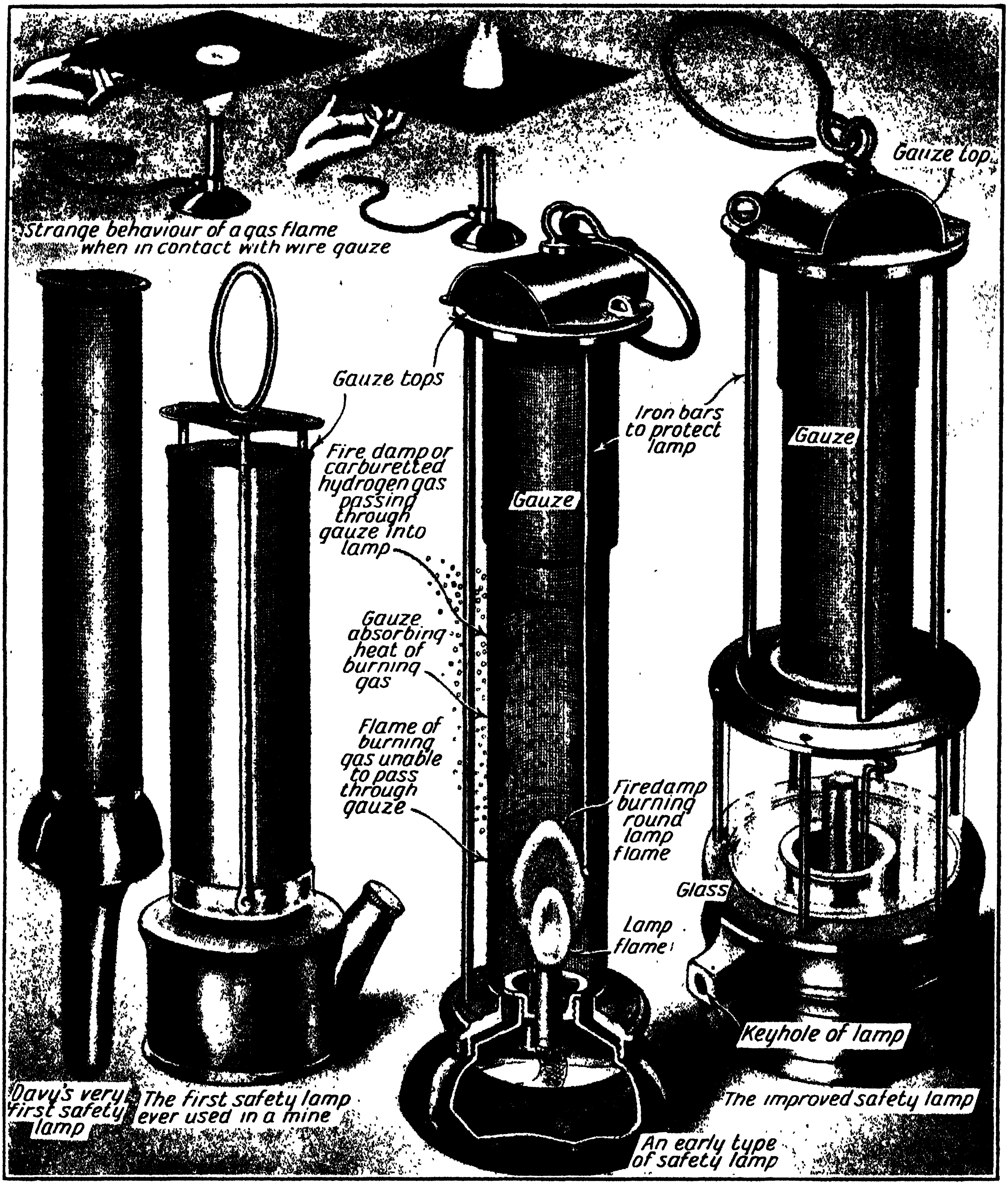
THE BEAUTIFUL WORMS THAT LIVE IN THE SEA

The sea-worms, members of the Annelid family to which our common earthworms belong, are of very varied forms and colours. Their different shapes can be seen from this picture, which shows a number of species. At the top is the Eunice, which has many organs of locomotion. Its digestive system is such that it has been described as having 280 stomachs. On the right are seen specimens of the Serpula, whose heads bear beautiful coloured plumes, which serve as breathing apparatus. It is the Serpula worms that cover shells and pieces of pottery in the sea with the interlacing chalky tubes that we often see. The creature in the middle is the Terebella, which forms a protective tube for itself of sand and fragments of shells. Various other species are also seen in the picture

THE GIANT HERON AND ITS GIANT NECK

In this photograph showing two specimens of the giant heron of Africa we see the wonderful flexibility of the bird's neck. One heron has the long neck extended and the other has it lowered and resting on the body. When herons are standing in the water watching silently for fish, they always have the head drawn back ready to strike. A heron's neck has the same number of bones as a penguin's

THE MINER'S LAMP AND WHY IT IS SAFE



One of the most valuable inventions of the nineteenth century was the miner's safety lamp, which has saved hundreds of thousands of lives in mines where fire-damp, or carburetted hydrogen, a dangerous gas, is formed. This gas when mixed with ten times its volume of air explodes if it touches a flame. Sir Humphry Davy and George Stephenson, working independently, produced in 1815 safety lamps which could be used with impunity in an atmosphere laden with fire-damp. Davy's lamp came into general use. Its principle is shown in these pictures. If a piece of fine wire gauze be held over a gas burner which is turned on, the gas will pass through the mesh of the wire. Now if a match be applied underneath the gauze the gas will catch light there, but the flame will not pass to the upper side. Similarly if the match be applied to the upper part of the gauze, the flame will burn there, but will not pass through to the lower part. Davy enclosed his lamp burner in a cylinder of wire gauze. When the lamp was placed in a chamber containing fire-damp this gas passed through the gauze to the lamp flame and burnt inside, but the flame did not pass out and fire the gas outside the gauze. The reason is that the flame has so much of its heat conducted away by the gauze that the heat outside is not sufficient to ignite the gas. So that the miner may not open his lamp in the mine, each lamp is now locked before he goes down

WHY WE COOK OUR FOOD

Civilised man cooks most of his food before eating it, whereas in the very early days primitive man ate his foods raw. What is the reason for cooking food, and what changes does cooking bring about? It is important that we should know something about this matter, and here we learn many interesting things about cook ng—why the meat changes colour, why potatoes get soft in boiling, and why the fish sputters when it is put in the frying-pan

THERE are several reasons why we usually cook our food before eating it. For one thing, the food is rendered more pleasing to the eye and more agreeable to the palate. Then, by cooking, some foods become more easily digestible, though this is not true of all, and another very important reason for cooking food is that it is to a very large extent sterilised by the heat and will keep for a longer period.

Take, for example, meats. No animal parasite that can be found in meat is able to withstand a temperature of 70 degrees Centigrade. All our ordinary methods of cooking, therefore, render meat free from such infection, but there are various bacteria which, when present in the inside of the meat, are not killed by the temperatures of ordinary cooking. It is not true, therefore, to say, as some books do, that cooking destroys all the microbes and other living things which may be present in the food.

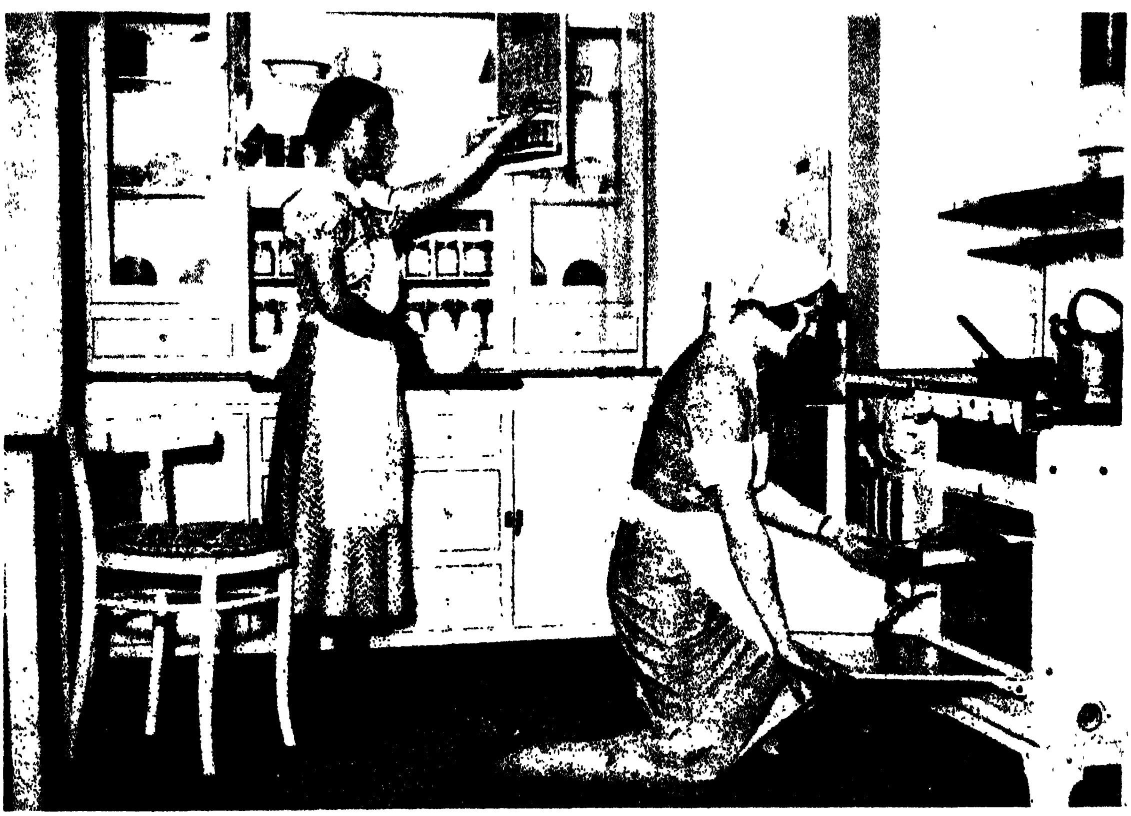
While it is true that cooking makes vegetable foods more easily digestible, this is not true of animal foods. In their case digestion is less easy after cooking than before.

Perhaps in an indirect way, however, the cooking of meats helps digestion, for it makes the food so much more attractive and palatable that the pleasing nature of the food after cooking calls forth a more profuse flow of gastric juice, the fluid in our body which digests the food.

Let us see what the effect of heat is upon the different substances in our foods. First of all there are the proteins, which build up our bodies. The effect of heat upon these is to coagulate or harden them. We see this in the case of the white of an egg, which when raw is fluid and can be dissolved in water, but after cooking is hard and insoluble. The carbohydrates in food which consist of starch and sugar are very much affected by heat. A dry heat, as in baking, converts starch into a soluble form, and moist heat causes the grains to swell so that the indigestible cellulose envelope of the grain bursts and the starch inside is released and turned into a jelly. In both cases the starch is rendered digestible.

Sugar, another form of carbohydrate, is inverted, as chemists call it, by cooking, which turns it into a digestible form.

The other substance in our foods, the fat, is less affected by heat than the proteins and carbohydrates. But fat which has been heated and allowed to cool again often becomes granular, as in the case of dripping and fried bacon fat. This is due to the driving off of water, and the fat is then more digestible than it was before.



The kitchen is a very important part of the house, for it is there that the foods we eat are prepared by cooking to make them both appetising and digestible. That cooking should be done correctly is much more important than most people think. Here is a modern kitchen with an electric oven where the cooking can be regulated by an even heat

Now let us consider the effect of cooking on the chief foods which we eat, such as meat, fish and vegetables. When we cook meat we decompose the red colouring matter in it and so change its raw appearance. But in doing this it is important not to cause the solid proteins to become too hard.

Baking and roasting are practically the same process, but in the case of roasting we apply the heat to one side of the meat at a time, whereas in baking the heat is applied all round at once.

The great aim in cooking meat is to see that all the flavouring substances are retained in it, and this is best done by sealing up the surface of the meat at the outset, so that during the cooking the salts and extracts which give the flavour cannot escape.

The sealing process is brought about by subjecting the meat to a high temperature at the start. Then when the outside is sealed up, so as to imprison the flavouring substances, the cooking should be continued by exposing the meat for a long time to a lower temperature.

In roasting or baking, the meat would tend to dry up, but this is prevented by basting, that is, by pouring fat from time to time over the joint. The real reason for doing this is that we cover the surface of the meat with a kind of varnish of fat which keeps in the moisture.

A grilled chop or steak is always much more appetising than when the meat is cooked by frying, because the higher temperature in grilling seals up the surface of the meat, preventing the escape of the flavouring substances, and at the same time the chop or steak, being thin, is cooked right through practically at once. The puffed-out form of a grilled chop or steak, which is a sign of good cookery, is due to the water vapour produced by the heat from the fluids in the meat being unable to escape.

Roasting and baking, when done properly, not only preserve the flavour of the meat, but develop by the chemical changes that are set up certain substances which are themselves very palatable. The dark brown sticky substance which we see on a well-cooked joint, and which is very savoury, is known as osmazone.

In roasting and baking, as well as in boiling, it is a great mistake to have too high a temperature. Experiments show that meat will cook as quickly at a temperature of 175 degrees centigrade, as at 195 degrees. If the meat be cooked at a lower temperature, as at 100 degrees centigrade, that is, 212 degrees Fahrenheit, much longer is required in the process, but the chances of over-cooking and spoiling the meat are less.

"Boiling" is an unfortunate term for the cooking of meat by moist heat, for it is neither necessary nor desirable to subject the meat to water at boiling point. At a lower temperature the red colouring matter is decomposed and made brown just as well as by boiling water, and the meat is not hardened by the proteins being coagulated too much as they are when the water is boiling.

Dr. Robert Hutchison, the great authority on food, says that if two eggs are taken and one is kept in water at a temperature of 175 degrees Fahrenheit for ten or fifteen minutes, and the other for an equal length of time in boiling water, it will be found at the end of the experiment that the contents of both are solid throughout, but that in the case of the former they consist of a tender jelly, whereas in that of the boiled eggs they are dense and almost leathery.

What is true of the egg is true also of meat. Actual boiling hardens the proteins and should be avoided. If the meat is being boiled to produce soup, then, of course, it does not matter that the flavouring substances in it are dissolved in the water. But if the meat is to be eaten, then the less the substances are dissolved the better. That is why when boiling meat as small a quantity of water as possible should be used, for the more water there is the more will the soluble substances in the meat be dissolved.

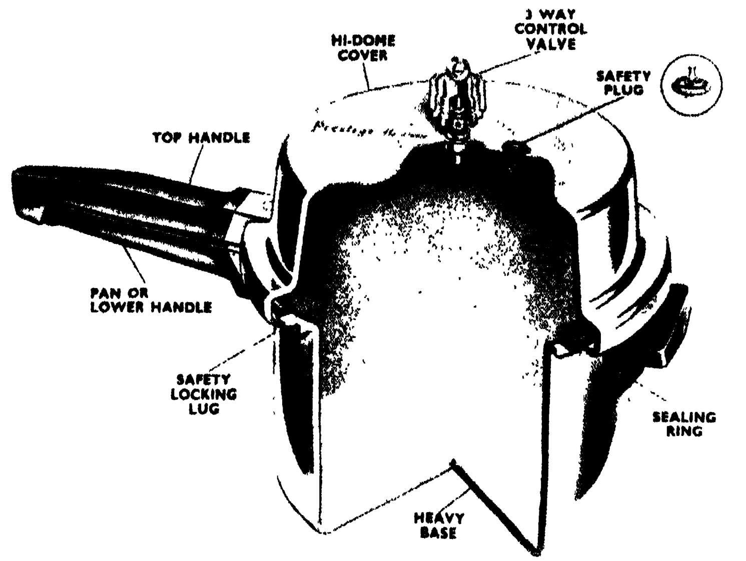
Here again, as in the case of roasting meat, the outside should be sealed up with a layer which will shut in the soluble substances. This is done by plunging the raw meat into boiling water and leaving it there for a few minutes. The proteins in the fibres of the surface become quickly coagulated, and thus the inside is sealed. But after this is done, for the actual cooking, the temperature of the water should be lowered and the cooking allowed to proceed only slowly.

Stewing is often regarded as a form of boiling, but the process is really the opposite to boiling. When boiling meat to cook it we do all we can to keep in the flavour and juices, and merely use the hot water as a medium for conveying heat to the meat. In stewing, however, the water is not only a heat-giver, but a solvent for extracting the juices from the meat.

Another method of cooking is that of frying, and this is used particularly in the case of fish. Successful frying depends upon the food being exposed suddenly to a very high temperature, so that the proteins of the surface may be coagulated to keep in the flavouring substances. The fish, being thin, is cooked almost instantaneously.

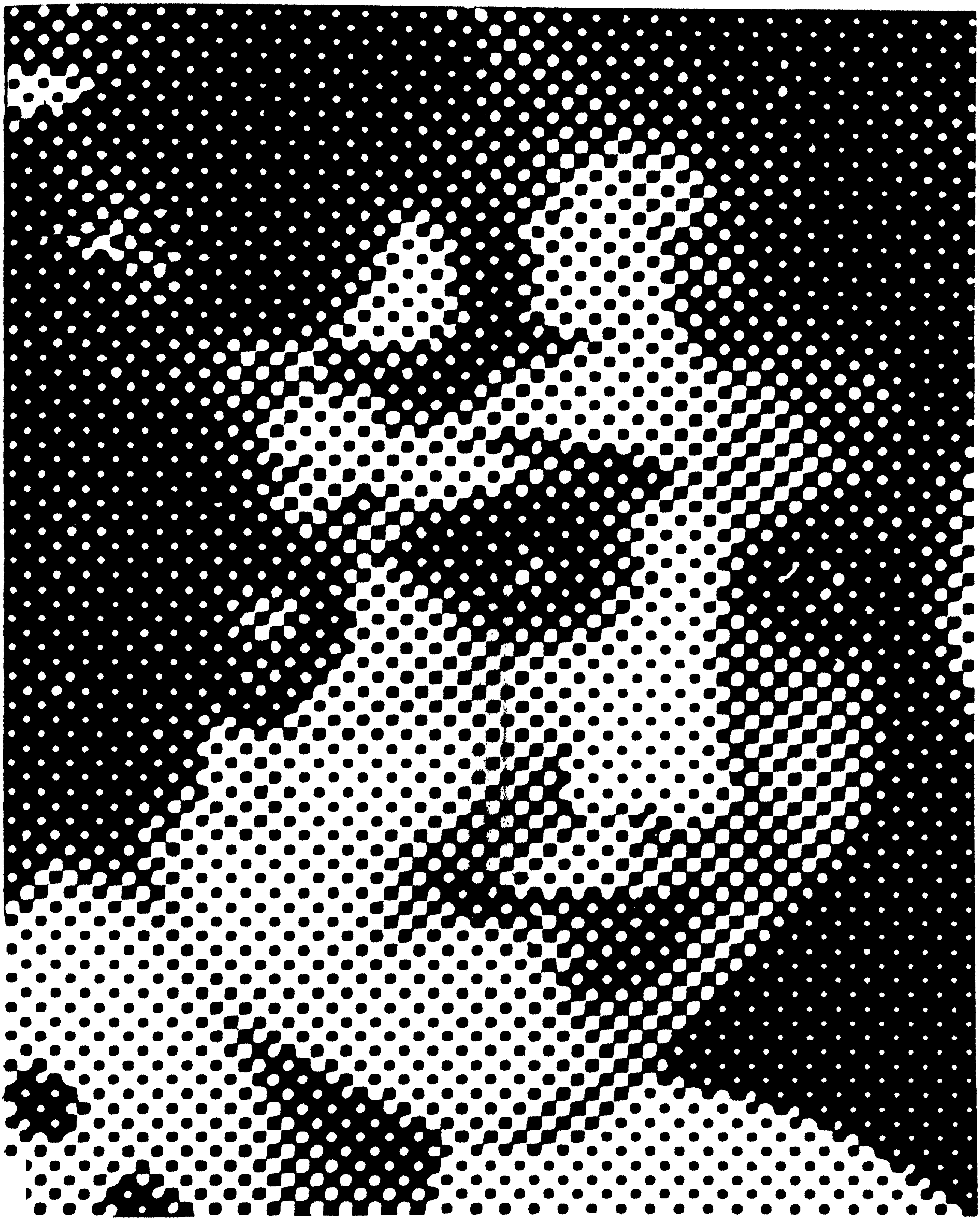
The high temperature required is obtained by using fat or oil, which is heated in the frying-pan to its boiling-point, that is, a temperature of 350 degrees Fahrenheit or more. The fish or other object to be fried is then plunged into the boiling oil and the sputtering and cracking which occurs is due to the moisture at the surface of the fish which is suddenly converted into steam.

It is quite wrong to regard the fat used in frying as merely a means of preventing the fish from adhering to the pan. It is only when the fish is immersed in the boiling fat that it is really fried.



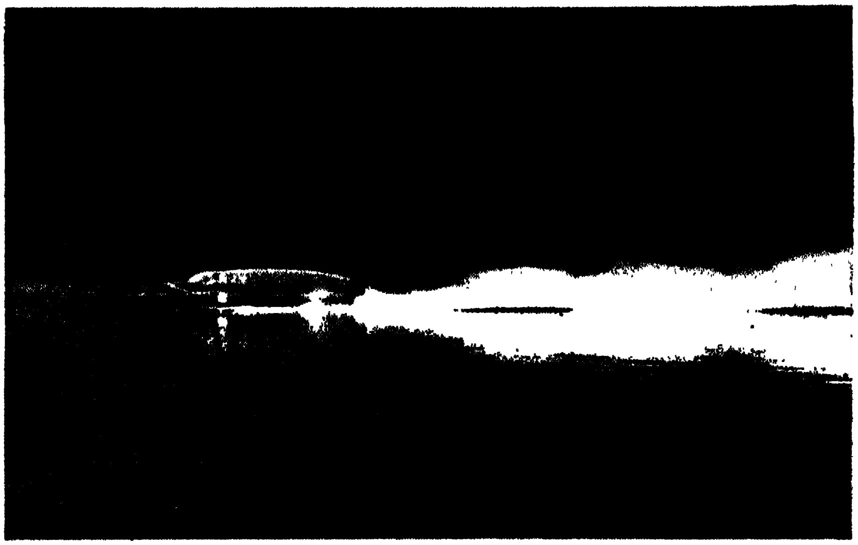
For the quick cooking of food an autoclave or pressure cooker is used. It consists of a strong metal pot with a lid which locks over it by means of a groove and ring. When the lid is in position no steam can escape ; the greater the steam pressure within the pot, the more securely the lid is held on. The lid cannot be removed while the steam pressure remains. The lid is fitted with a control valve which can be set to the pressure required for cooking any particular food. When the desired pressure has been reached, steam escapes through the valve and blows a whistle to warn the user. If the valve fails, the steam blows out a safety plug. With the Prestige cooker illustrated above several different foods, each in its own basket-container, can be cooked together without the flavour of one food affecting the other.

HOW A PICTURE CAN BE PRINTED IN A BOOK



Before a picture can be printed in a newspaper or a book like this a metal plate must be made in the manner shown on pages 596 and 597. As the printing ink is all black the different tones of the picture can only be obtained by breaking the picture up into small dots. These will all print black, but the lighter parts of the picture will have smaller dots than the darker parts, and thus the varying size of dots at different parts gives the different tones of the picture. On this page a small picture of a girl's portrait has been greatly enlarged to show how the dots vary in size. In the darker parts they run into one another and print almost solid black

JET SPEED-BOAT THAT JUMPED THE WATER BARRIER

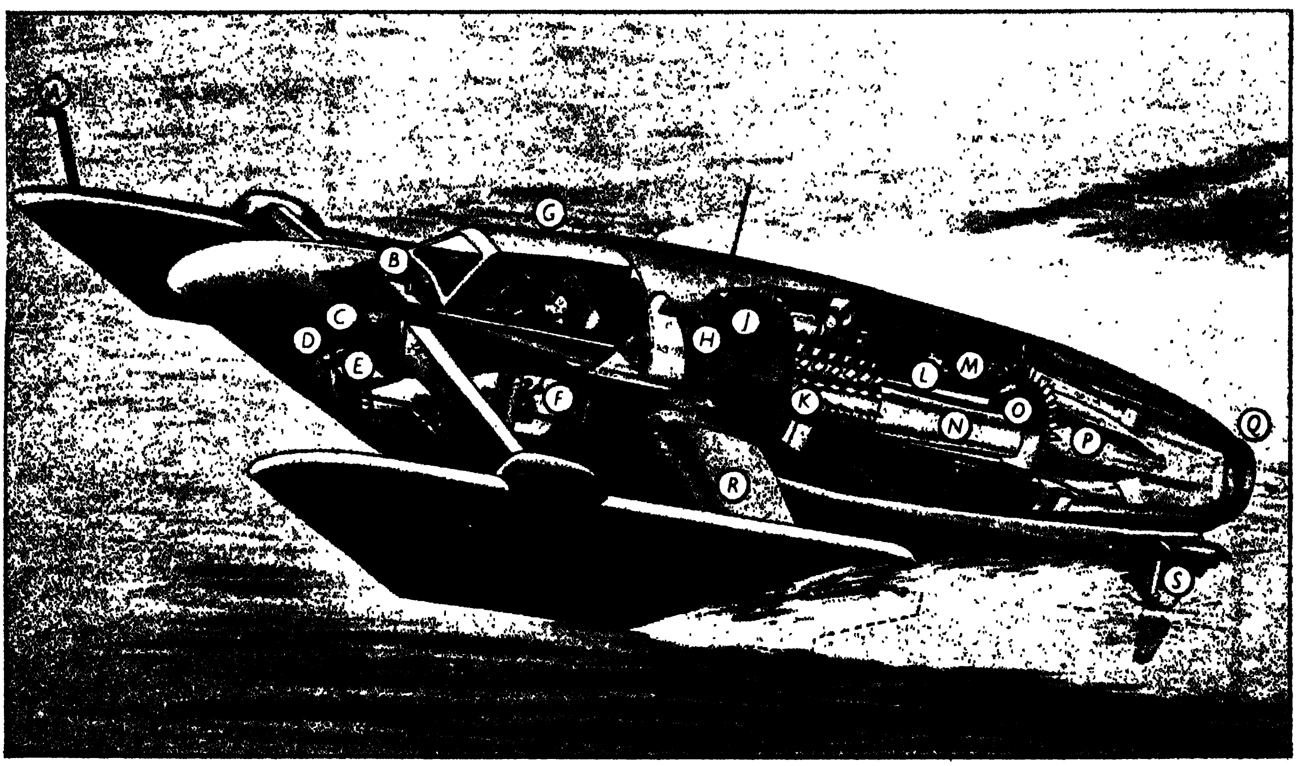


The photograph on the right shows the jet-propelled Bluebird II in which Donald Campbell set up a new world water-speed record of 239·07 miles an hour. The record-breaking run was made on Coniston Water, Lancashire, on November 8, 1957, and the officially-recognized speed was the average of two runs over the measured mile. On the first run Bluebird's speed was 260·1 miles an hour, and on the second run was 218·024 miles an hour.

While setting up the record, Bluebird broke through what is called the water barrier. This is a condition that occurs when a boat is travelling at speed in the region of 200 miles an hour, and is thought to be caused by the forward movement of the boat so compressing the water in front of it that the water builds up in a solid mass, making an obstacle rather like a brick wall. Its effect is a violent pitching movement which, if the boat is not carefully designed for high speed, may smash the vessel to bits.

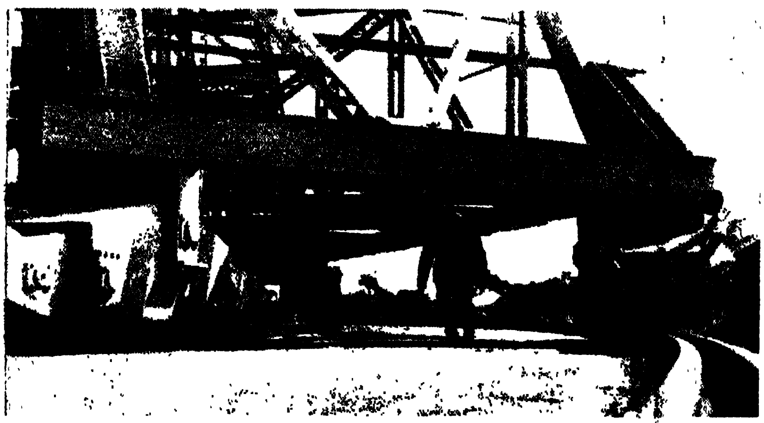
The water barrier is believed to have been responsible for John Cobb's fatal accident on Loch Ness in 1952, when his speed-boat Crusader disintegrated while travelling at 240 miles an hour.

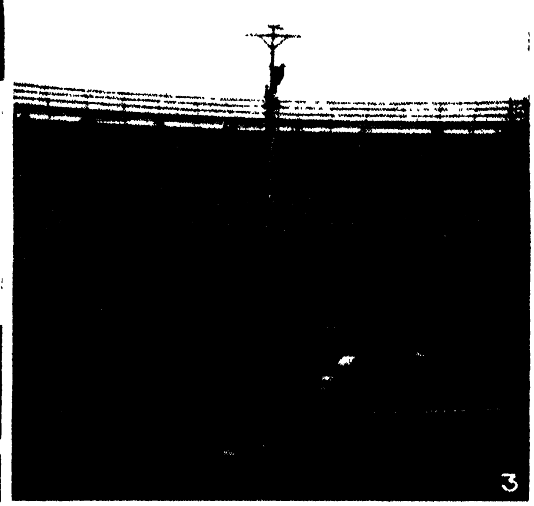
The drawing below is of Bluebird II cut away to show you what the boat is like inside. To prevent it from turning over when travelling at high speed, the boat is fitted with two stabilising floats, like those of an outrigger canoe. While travelling at speed, the navigator is in constant radio communication with observers on shore, who can thus warn him of any objects floating on his course. If a motor boat travelling at Bluebird's speed struck even a small piece of floating debris it would either turn over or sink. The drawing is lettered to indicate the chief parts as follows : A, pitot head for giving the speed of the boat ; B, radio transmitter ; C, main spar ; D, linkage to rudder ; E, throttle, operated by foot ; F, throttle, operated by hand ; G, cockpit cover ; H, guard to prevent anything but air from entering the jet engine ; J, starter motor ; K, compressor for jet turbine ; L, fuel nozzle ; M, combustion chamber for jet engine ; O, turbine wheel of jet engine ; P, engine thrust-cone ; Q, exhaust vent ; R, spar supporting floats ; S, rudder. The jet engine installed in Bluebird II works in exactly the same way as that illustrated and described in page 248.



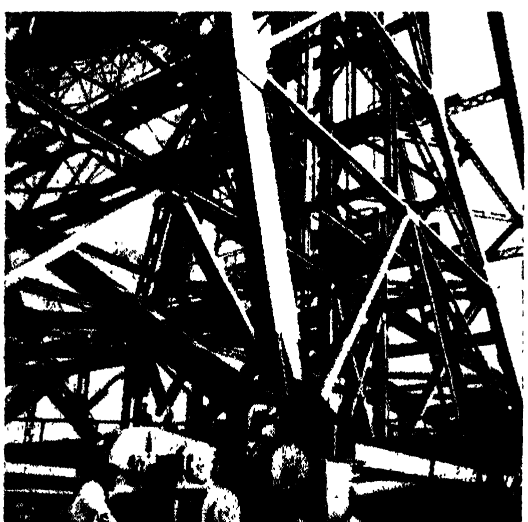
TELESCOPE THAT LISTENS TO "STAR BROADCASTS"

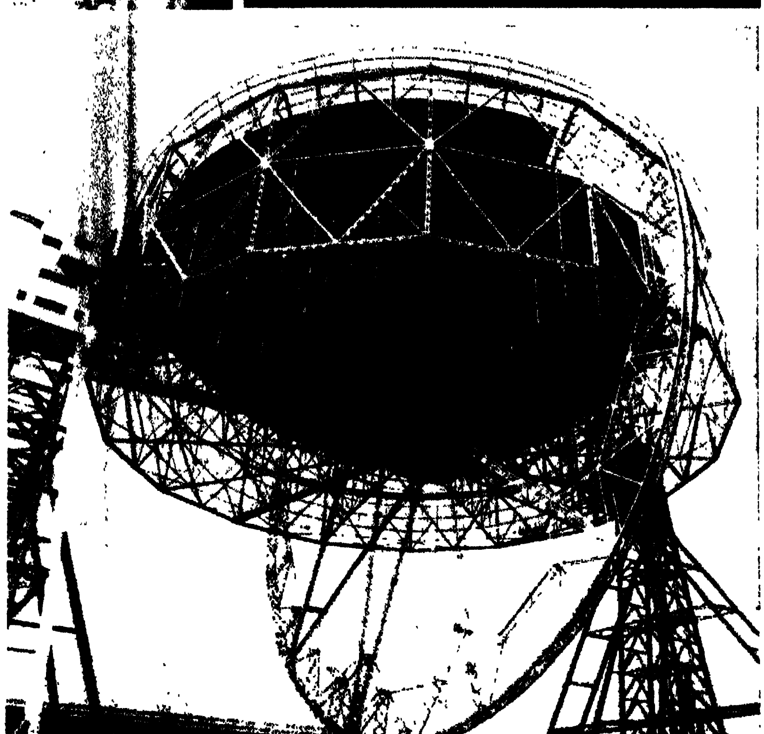
As explained in page 287 some of the most distant stars transmit radiation which can be detected by a radio telescope in much the same way that a broadcast programme is picked up by the ordinary household receiver. As these photographs show, however, a radio telescope is a much more massive instrument than an ordinary receiver and uses as aerial a huge steel bowl carried on great girders mounted on bogies running on rails. 1. Control room from which the huge telescope, which weighs 1,500 tons, can be directed to any part of the sky by pressing a few buttons. 2. Two of the electrically-driven bogies which run on a track 230 feet in diameter. 3. Inside the bowl aerial which is 250 feet in diameter and weighs nearly 750 tons. Originally open mesh, the bowl was afterwards covered with plating.



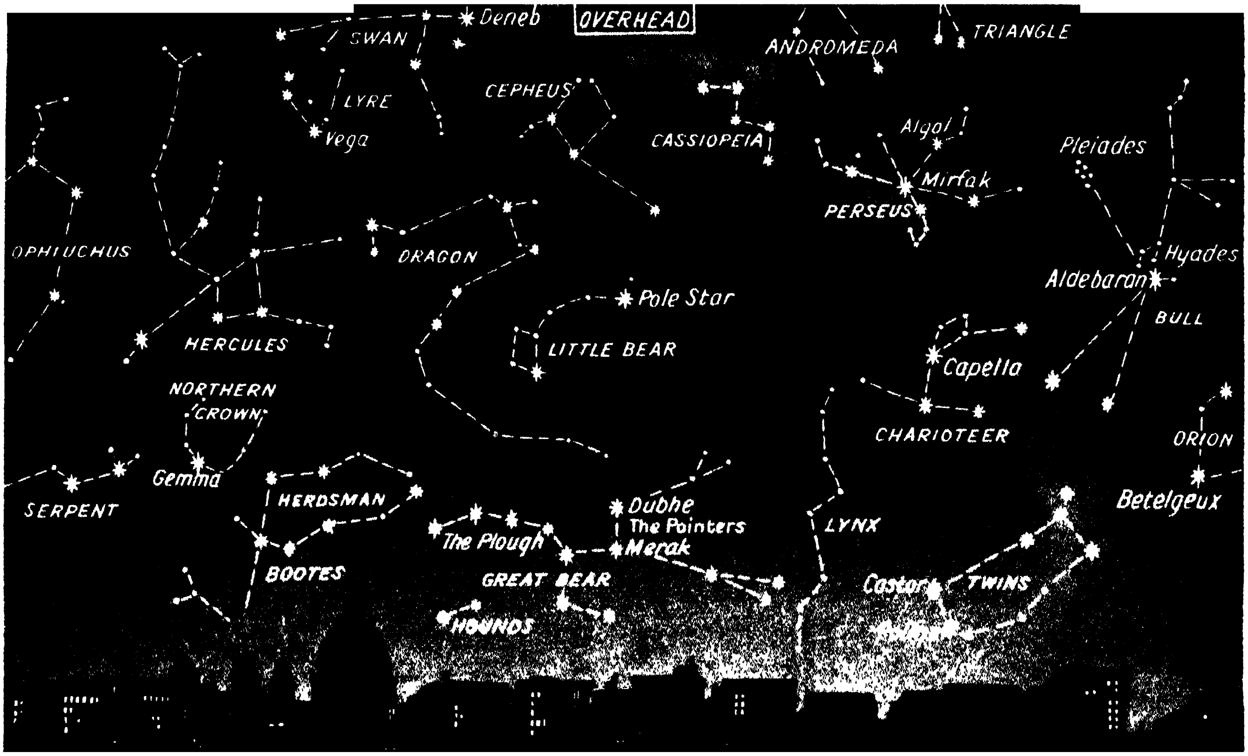


4. One of the 400 h.p. electric motors and bogies which move the mass of steel girders supporting the reflector aerial. 5. The reflector aerial supported between its two steel towers. The arc-shaped girder passing below the reflector supports the aerial as it is moved from the vertical to the horizontal. Other details of this wonder instrument for "listening-in" to stars are given in page 287.

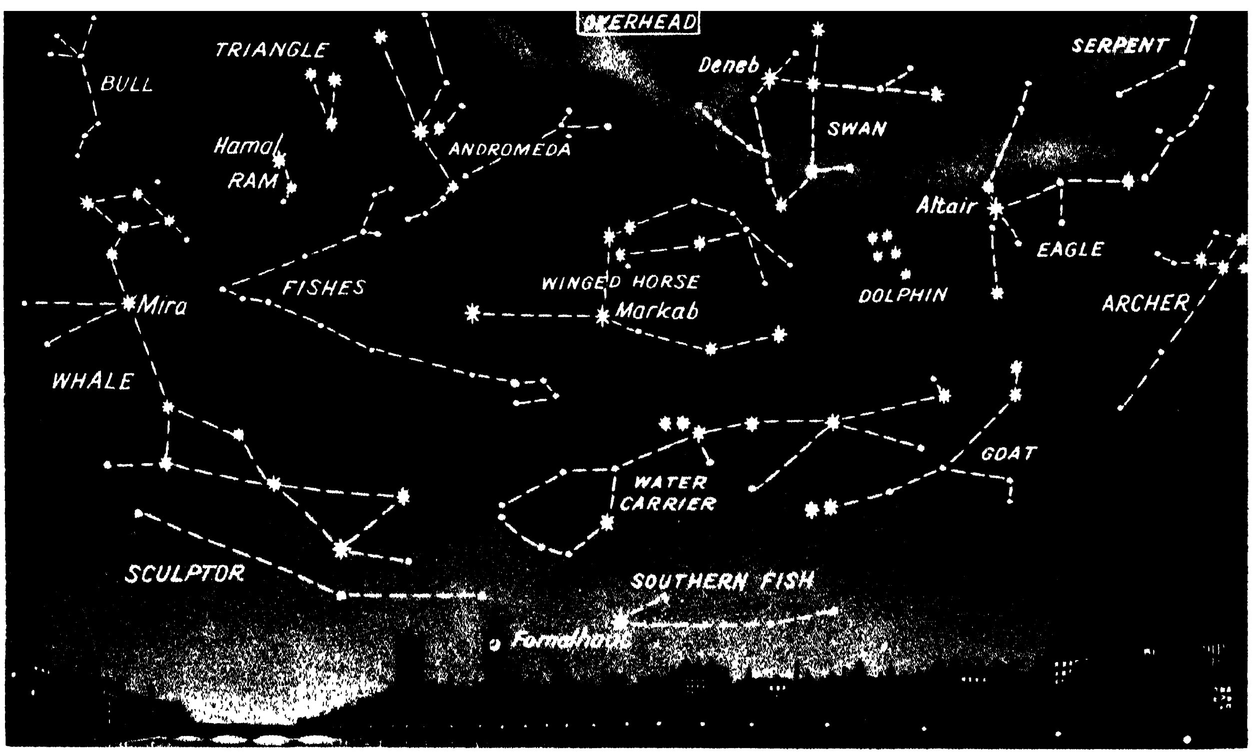




THE CHIEF STARS LOOKING NORTH AND SOUTH



In this picture-diagram we see the principal constellations or groups of stars in the sky as we look north in the middle of October at nine o'clock in the evening. Of course the most easily recognised of these groups is the Plough, part of the constellation of the Great Bear. We see its pointers, that is, the stars Merak and Dubhe, which point almost directly to the Pole Star, the point round which the other constellations circle. We see part of the Milky Way crossing the heavens on the right of the picture. The sky will have the same aspect as this in the middle of November at seven o'clock in the evening, and in the middle of December at five o'clock



Here we see the night sky at nine o'clock in the middle of October looking south. Again we see part of the Milky Way. Everyone should be able to pick out the principal constellations, and with the aid of these picture-diagrams and those appearing on pages 130, 415 and 718 we can quickly learn how to do this. When we have identified one of the constellations it is quite easy with the chart to detect the others. It is a great convenience in identifying the various stars that men have grouped them into these constellations. The ancients fancied they saw some resemblance to the objects named, the Bear, the Dolphin and so on, but we can see none to-day

WONDERS OF THE SKY

NATURE'S CURIOUS PINHOLE CAMERA

The foliage of the trees sometimes acts as a pinhole camera and images of the Sun are projected on the ground underneath. When an eclipse of the Sun is taking place these images are in the form of little crescents, and are a very interesting sight, as explained on this page

DURING a solar eclipse, if the sky is unclouded, there is a very interesting phenomenon which we can see, namely, the projection of many images of the Sun, partially eclipsed, thrown upon the ground under a tree that is clothed with foliage. A picture of this interesting phenomenon is given on this page, and the next time there is a partial eclipse of the Sun we should look out for these images underneath the trees.

Before we can understand why there should be so many representations of the Sun upon the ground we must carry out a little experiment. We take an ordinary cardboard pillbox and replace the card of the lid with tissue paper. Then in the bottom of the box we make a small hole with a pin or needle.

If now we hold the pillbox in front of the flame of a lighted candle, we shall see an image of the flame upside down shining through the tissue paper. Why the image is upside down we see in the picture of the camera on page 177. The rays of light cross one another as they go through a tiny opening, and so what is at the top in the object is at the bottom in the image, and vice versa.

Watching the Flames

Now let us make a second hole in the bottom of the pillbox with the pin. We hold the box once more in front of the candle flame, and now we see two images, one coming through each hole. So we might go on, making further holes, and at each addition we should see another image of the flame on the tissue paper. We must not make the holes too close together, or we shall find that one image will interfere with another and be less distinct.

Let us now carry out another experiment. We can place a very dark blind over the window of a room facing the Sun and then make a hole in it. A beam of light from the Sun will pass through the hole, and if we hold a piece of ground glass such as that which we find in a transparent drawing slate, before the hole, we shall see thrown on this glass screen a little image of the Sun. If we prick a second hole in the blind there will be a second image, and so on.

The same kind of thing happens when the Sun is shining through a tree that is in full leaf. The openings between the leaves are like so many little pinholes, and as the Sun shines down and through these openings, images of the Sun's disc are thrown upon the ground below.

Images of Different Shape

In ordinary times these images are circular or oval according to the time of day. When the Sun is shining more or less directly down upon the tree the images are circular, but when he is low on the horizon then the images are seen in perspective, and are oval in shape.

The interesting point, however, is that when an eclipse of the Sun takes place and its disc, owing to the passage of the Moon across it, becomes like a crescent, the images of the Sun that are cast upon the ground beneath the tree are like so many little crescents.

It is interesting when there is an eclipse of the Sun to catch on a screen an image of the solar disc with the indentation produced by the passage of the Moon between us and the Sun. We can obtain such an image if we expose to the Sun during a partial eclipse a card with a pinhole pricked in it. The rays from the Sun passing through this small hole will throw the image of the partly eclipsed Sun on the screen, just as was done when a hole was pierced in the dark blind over the window.

The foliage of the tree when the Sun's disc is projected through the openings between the leaves is really acting as a pinhole camera, and the ground underneath corresponds with the ground glass screen at the back of the camera.

As a preliminary to examining the solar crescents under a tree during an eclipse, which we may not have an opportunity of doing for some time to come, we may carry out a simple and interesting experiment in our home on any evening.

Most of our houses are now lighted by gas or electricity and in one of the rooms probably there is a chandelier with the lights hanging from the ceiling.

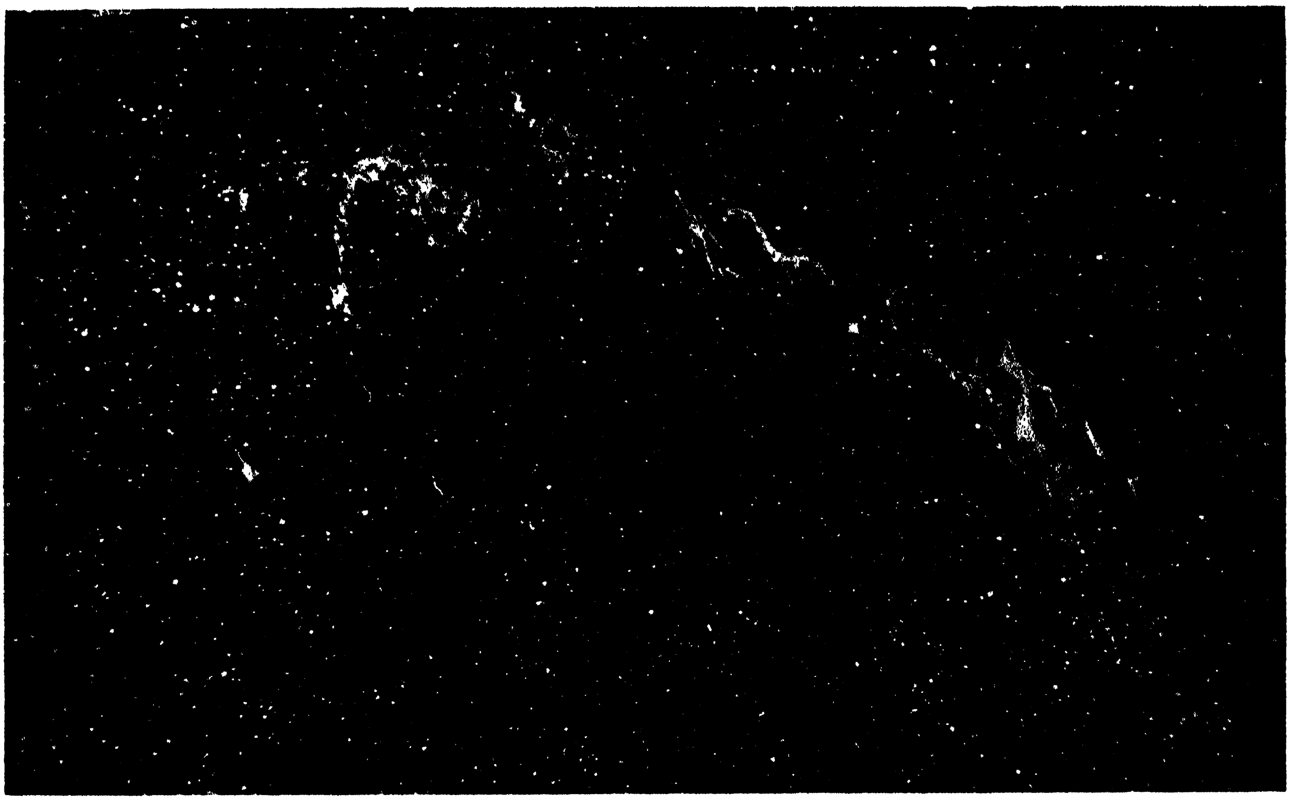
A Simple Experiment

Well, if we prick a hole in a card and hold it underneath the light near the table, we shall see a minute representation of the light or lights above. If these are electric lamps we shall see the shape of the illuminated filament on the table.

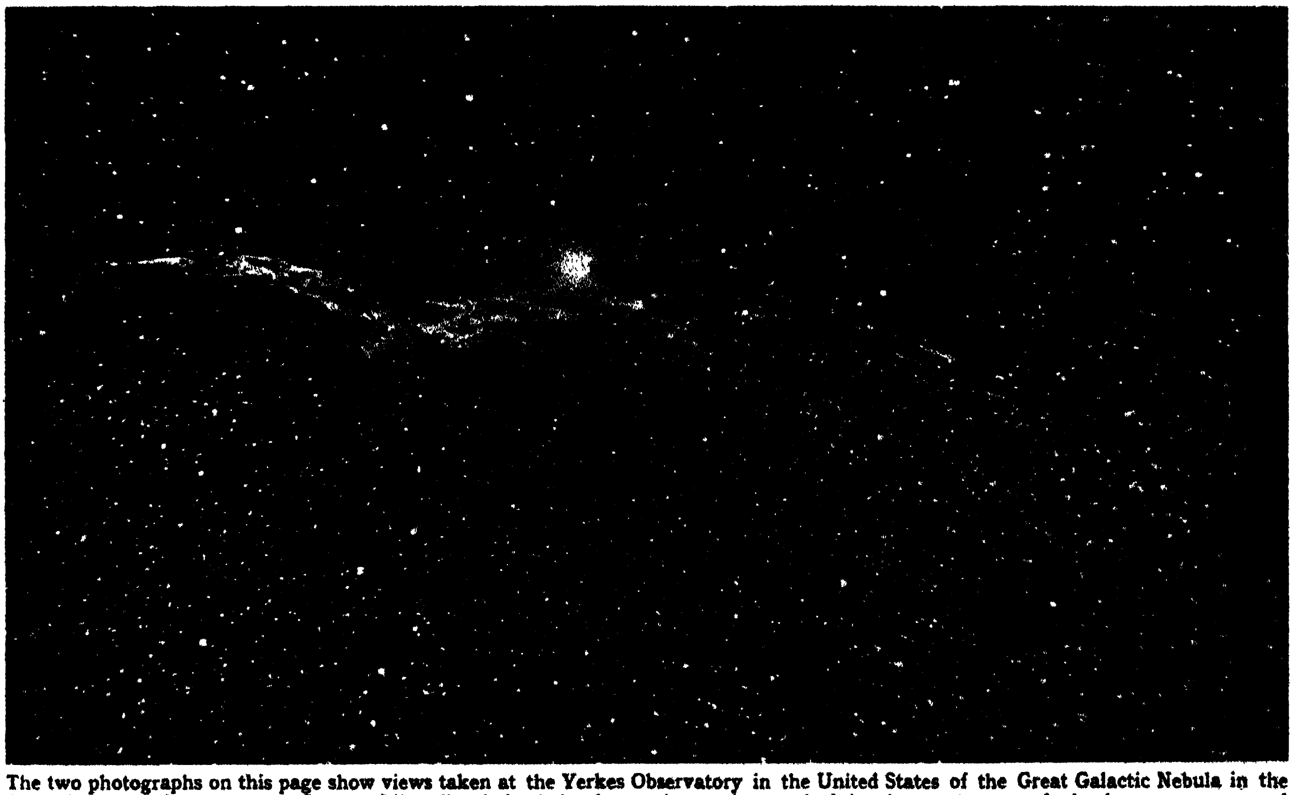
Now if we prick other holes in the card, we shall find thrown on the table, or whatever surface is underneath, as many representations of the lights above as there are holes in the card.

The many images of the partially eclipsed Sun projected on the ground by the light passing between the leaves of a tree

THE GREAT WISPS OF GAS IN THE SKY



The great spiral nebulæ such as that in Andromeda are now known to be vast universes like our Milky Way system, but lying far beyond. Then there are what are known as planetary nebulæ, believed to be stars in the Milky Way system surrounded by enormous luminous atmospheres. A third class of nebula is shown in the photographs on this page. Such nebulæ are called galactic, because they form part of our galactic or Milky Way universe. They are of irregular shape and look like wisps of glowing gas, which they probably are



The two photographs on this page show views taken at the Yerkes Observatory in the United States of the Great Galactic Nebula in the Constellation of Cygnus or the Swan. Like all nebulæ it is of vast size, and enmeshed in the great mass of glowing gas are several stars. The fantastic shape of the nebula is due to the fact that parts of this great drawn-out cloud of gas are opaque, while other parts are made luminous by the radiation of the stars in it. The density of the gas varies greatly. In parts it is almost incredibly thin

THE OIL THAT COMES FROM THE ROCKS

Oil in the present century has largely usurped the place that was held by coal in the nineteenth century. When we realise how much the world to-day is dependent upon oil, it seems wonderful that the first modern oil well was sunk in America so recently as 1859. There is no doubt that the Ancients tapped oil which lay near the surface of the ground, but they had no idea of the great stores that were hidden deep down in the Earth's crust. Something about the origin of oil is told on this page

A VAST amount of power stored up in the Earth's crust is now being utilised by man to carry him to and fro over the Earth's surface, and to work his machinery. Some of this stored-up power is in the form of coal, and in the nineteenth century coal was king.

But now coal has been to a large extent supplanted by another form of stored-up power, namely, oil. This, too, is obtained from the dark places of the Earth's crust. It must be bored for, and like coal it is really a form of stored-up sunshine.

There is more mystery about the origin of the oil than about the coal. We know that coal consists of the buried forests of past ages. We find in the coal measures complete trunks of pre-historic trees and tree ferns, and now and again in our coal-scuttles we see the impression of a leaf or stalk on the coal that has been delivered to us for our fires. There is no doubt whatever about the origin of the coal measures.

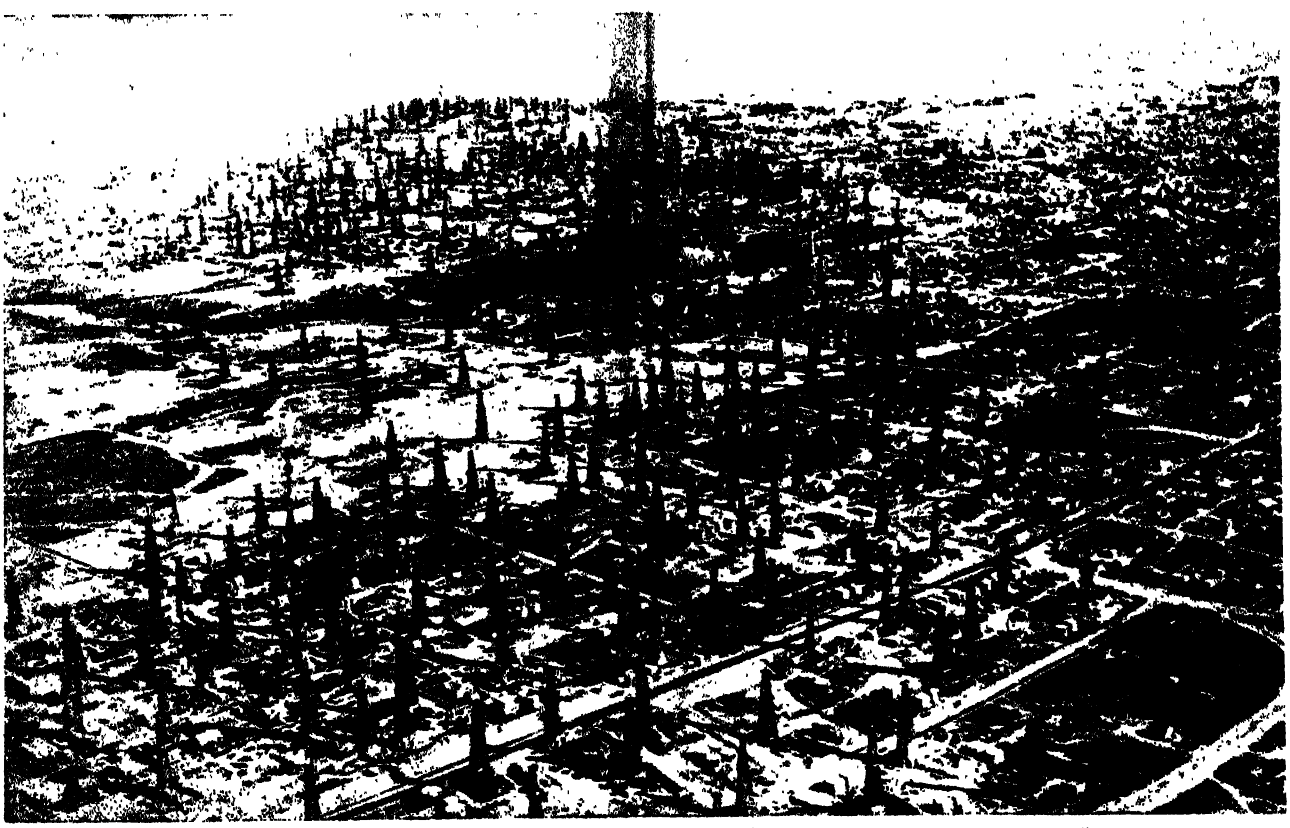
But when we come to oil, men of science are not so sure, although it is generally agreed by the majority of scientists that while oil is a mineral at the present time, it consisted in far distant ages of organic matter.

It is believed to have had an aquatic origin, and to have resulted from the decomposition of water plants and possibly of animals under the influence of pressure and heat working through a long period. The plants or animals, it is believed, were buried at the same time as the sediments that form the rocks, and probably most of the organic remains lived at one time in the sea.

Oil consists mostly of the two elements, hydrogen and carbon, which are found in animals and plants, and it is believed that the creatures from which the oil originated were not large forms of life, but small and even microscopic.

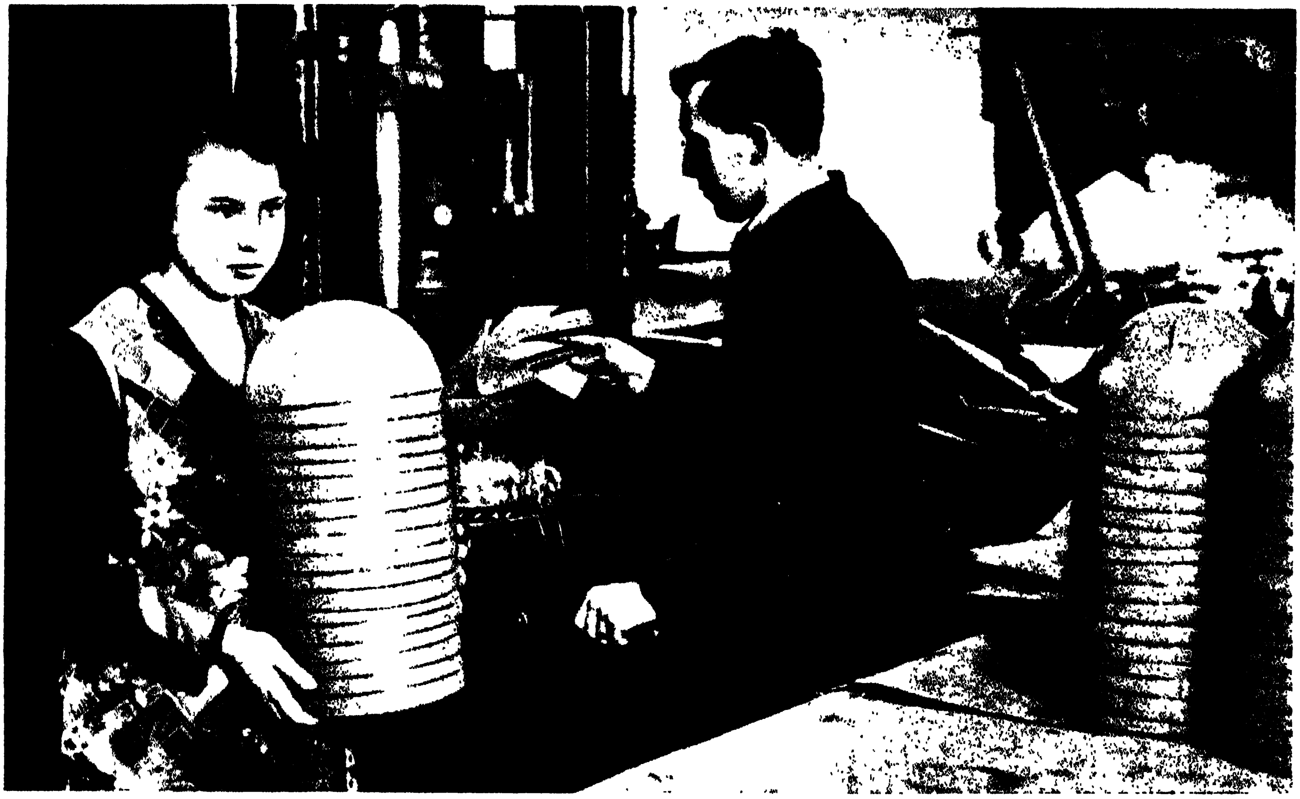
Ancient seas, it is thought, ebbed and flowed across the continents, leaving at each movement deposits of animal and vegetable matter with the muddy sediment, and this organic matter, being sealed up for long ages, decomposed very slowly, till at last it was changed into the form in which we now find it, namely, petroleum oil and natural gases. It must be remembered that natural gases are generally found in the same places as the oil deposits.

It should be mentioned that while some geologists believe the oil has come from both animal and plant life, one section thinks it is exclusively animal and another section entirely vegetable in its origin. A small group of geologists still adheres to the old theory that it is neither animal nor vegetable, but mineral in its origin, that is, that it has been produced from the minerals in the rocks under the influence of heat



This photograph shows the Signal Hill Oilfield of California, which is said to be the greatest concentration of oil wells in the world. But there are other oilfields, as for instance those in Mexico, Venezuela, Persia, Iraq and Russia, which show a similar forest of derricks. The world now produces nearly 600 million tons of oil a year.

MAKING MODELS OF THE GLOBE ON WHICH WE LIVE



The geography of the Earth on which we live is being more and more studied by means of globes, which give a much better idea of the Earth's surface than any flat map can do. Shapes are cut out by means of a punching machine and curved into hemispheres

Two hemispheres are then fastened together to form a globe, and the maps which have been prepared and printed in colours are stuck on this sphere in sections, after which each globe is carefully mounted on an axis and stand and is ready for use in the school or home

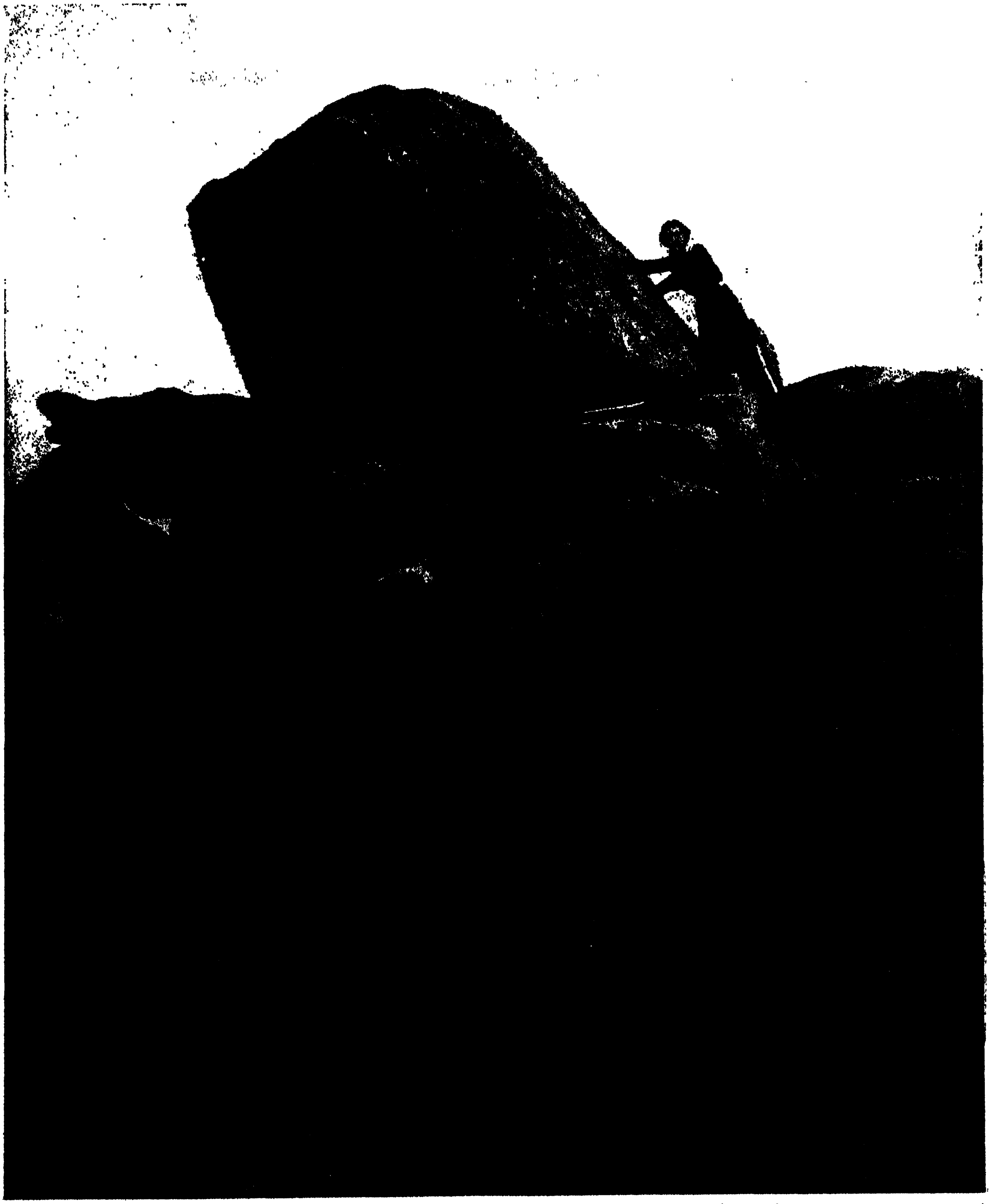
THE BIGGEST SUNDIAL IN THE WORLD

The people of Ancient Egypt used to tell the time by the shadows cast on the ground. They made a clock in the form of a shadow scale, as shown on page 444. But the changing length of the shadow cast by any object gave them a very good indication of the time of day. In this sense every tree and building became a sundial. The biggest sundial in the world is the Great Pyramid of Cheops, in Egypt, and the Ancient Egyptians were able to get an idea of the time of day by watching how far the shadow of its apex reached. In this photograph, taken from the top of the Pyramid, looking towards Cairo and the Nile, we see the shadow of the Pyramid cast for hundreds of feet across the country. The top of the Pyramid was originally pointed but is now flat, while the sides, now a series of steps, were once covered with smooth slabs of stone.

AN INDIAN TORNADO COMES AND GOES

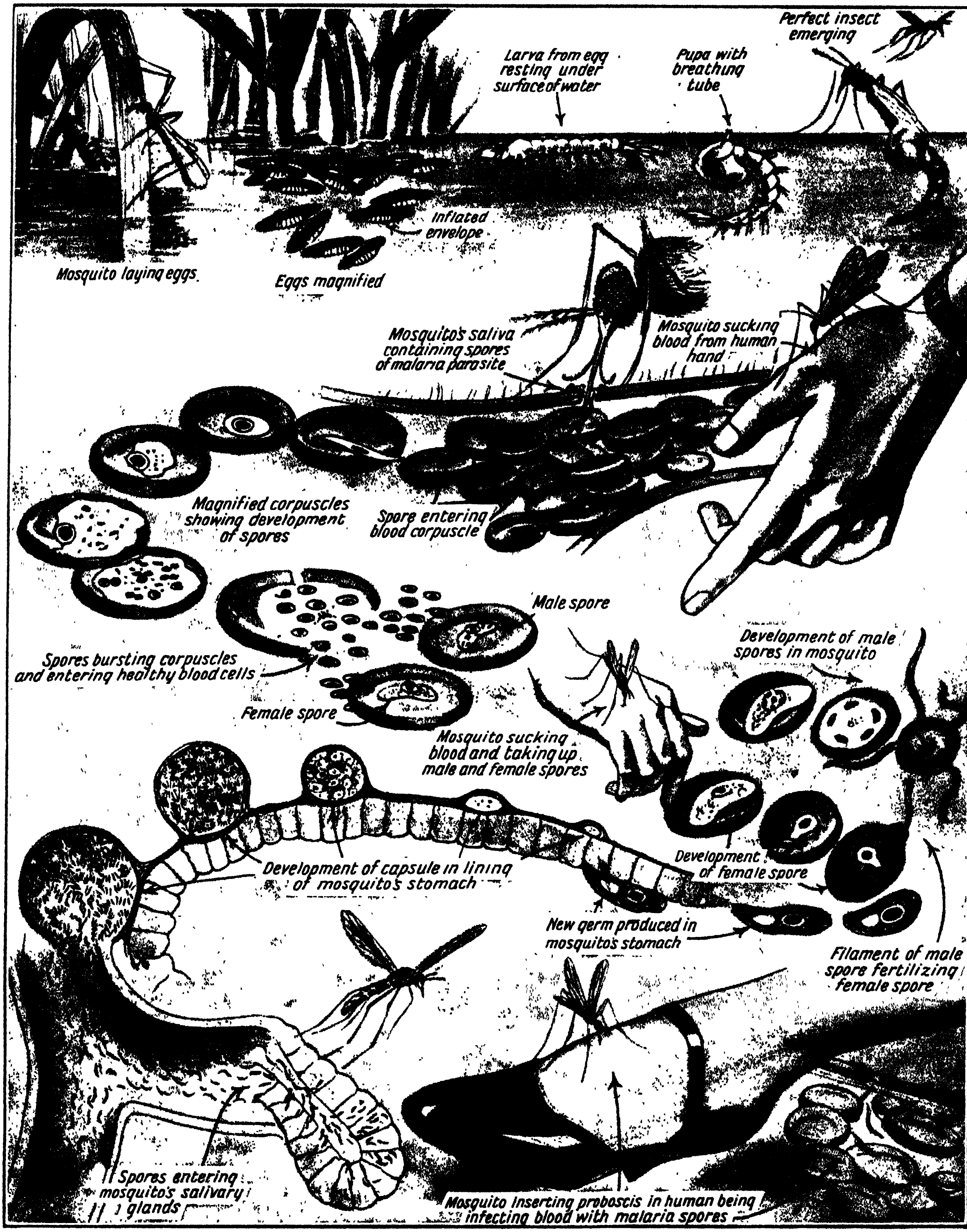
Although the United States is the country generally associated with tornadoes, these small but powerful whirling storms that do so much destruction in so short a time are sometimes experienced in other parts of the world. The four photographs on this page show the coming and going of a tornado at Peshawar in India. Like a great waterspout the tornado revolved rapidly beneath the threatening clouds, whirling here and there and changing its shape, till, as shown, it became smaller and smaller and at last disappeared. Apart from the terrible destruction that it does, a tornado is a very terrifying experience, for as it travels it makes a truly deafening noise

A FAMOUS CORNISH ROCKING-STONE



The famous Logan Stone situated near Saint Levan in Cornwall is now the property of the nation, and a very interesting stone it is. It is almost on the tip of England, and consists of a great granite block 17 feet long and 32½ feet in circumference at the middle. It weighs about 65 tons, and by a push of the hand can be made to rock. It rocks only in one direction, and there is a quantity of loose gravel near the points of contact which are the result of wear. The Logan Stone was not carried to the spot where it rests by a glacier, but is the result of the cracking and weathering of the mass of rock of which it once formed a part. At the beginning of the nineteenth century a naval lieutenant named Goldsmith, for a joke, threw the stone off its balance, and he was ordered by the Admiralty to replace it. He had to employ sixty men with a tackle, and the job took about nine weeks. The total cost of replacing the stone on its base was £124 10s. 6d. It was a useful warning to practical jokers not to play tricks of this kind.

THE STRANGE LIFE-STORY OF AN EVIL GERM



Here is the wonderful life-story of the malaria germ. The anopheles mosquito, in which the germ lives, is hatched from eggs laid on the water. It settles on a human being, pierces the skin to suck blood, and spores of the malaria parasite from the mosquito's body enter the victim's blood, where they develop. Another mosquito settles on the person and pierces the skin, and in doing so takes up some of the spores. The spores develop in the mosquito and new germs are produced in that insect. When it bites another person it inserts some of the spores in the victim's blood, and so the evil work goes on. In the human blood the spores develop and cause malarial fever. The corpuscles and spores are shown here greatly magnified

THE ROMANCE OF A GREAT DISCOVERY

If wars have slain their thousands, malaria has slain its tens, nay hundreds of thousands, and many historians and scientists now believe that it was this fell disease which was responsible, more than any other cause, for the downfall of the Greek and Roman civilisations. It was an unconquerable scourge till recent times, when a great English doctor, Sir Ronald Ross, who gave up his life to its study, discovered the whole life-story of the malarial germ, and showed how it could be conquered. Here is the story

Of all the scientific triumphs of the last hundred years it is doubtful if any has been of greater value to the human race than the discovery of the real nature of malaria. It is declared by competent authorities to be the chief of all diseases from which the human race has ever suffered, and it has been estimated that over one half of the entire mortality of mankind throughout history has been due directly or indirectly to malaria. In India alone to-day about 1,300,000 deaths result from malaria every year, and the financial loss to the United States from the disease is said to be not less than £25,000,000.

There are about three million cases of malaria in the United States every year, and millions of acres of rich and fertile land are rendered useless through the dread disease.

The word malaria means "bad air," and it was thought up till the end of the nineteenth century that it resulted from the gases and unwholesome odours given off by swamps. Men tried to prevent the disease, but failed, and all they could do was, by dosing patients with quinine, to reduce its intensity and give the patient some chance of recovery.

Malaria Alters History

The influence of malaria on human history is only now coming to be understood. It is believed that the downfall of Greece as a world power was due to the inroads of malaria, which undermined the health of the people and sapped their vitality. Even in modern times it influenced history, a striking example being the impossibility of cutting the Panama Canal till malaria had been conquered in that region.

The discovery that malaria can be abolished in a country if only certain precautions are taken is a blessing that has been brought to the human race chiefly through the work of a great Englishman, Sir Ronald Ross. Ross, who was a member of the Indian Medical Service, gave his life up to this great task, and he was successful.

Like so many real benefactors of the race, he has never been rewarded for his work. A general or an admiral who succeeds in killing large numbers of men is made a lord and given a fortune, but a man like Sir Ronald Ross receives practically no reward at all, and indeed spends so much of his own money in carrying out his experiments that he is worse off rather than better as the result of his successes. In years to come, no doubt, this Englishman will be placed among the greatest benefactors that the world has ever known.

The story of the conquest of malaria is a great romance. In 1880 a French army surgeon in Algeria discovered that malaria was due to a germ, and three years later Dr. King, of Washington, suggested that probably this germ was spread by means of mosquitoes, which were always found in great numbers in malarial districts. With this idea in his mind Sir Ronald Ross spent years trying to trace the real history of malaria, and he proved beyond a shadow of doubt that the parasite or germ which caused the terrible disease is dependent, for its transmission from human being to human being, upon a species of mosquito known as Anopheles. The name is from a Greek word which means hurtful, and certainly the name is a very true and descriptive one.

The young English surgeon used to go round pricking the fingers of native Indians and paying a rupee to each, in order to get adequate supplies of malarial blood for examination

To tell in detail the story of how the discovery was made would take more space than we can spare; but we may mention that Ronald Ross, as a young surgeon, went round pricking the fingers of natives and paying a rupee to each, in order to get adequate supplies of malarial blood. Then he used to examine these specimens patiently through the microscope, and on one occasion he watched a minute organism for three hours, without taking his eye from the instrument. When his holiday became due, he spent two months in the most malaria-stricken jungle he could find, and there contracted the fever himself.

A Last Minute Discovery

It is remarkable to think that when at last he was successful in discovering the malaria germ, it was during the examination of the very last mosquito of a batch. He had, from that batch, examined without result no fewer than a thousand mosquitoes' stomachs, and almost gave up in despair. When success came, however, he was so enthusiastic that he wrote a poem in celebration of the event.

Let us now explain exactly how malaria is caused, and how it is spread. People do not catch it by breathing bad air in swampy districts, however bad the air may be, nor do they catch it by being with people who have already got the disease, as they catch smallpox or scarlet fever. Here is the true story of malaria.

The germ or parasite which gives and spreads the disease lives and thrives inside the blood of anopheles. The life history of that mosquito is very much like that of the mosquitoes which we find in England. It lays its eggs on the water, but instead of forming them into a raft or boat like our English mosquitoes it lays them singly, each egg being provided with a kind of envelope which becomes inflated so that the egg floats. After a

time the larva changes into a pupa and in due course this develops into the perfect insect with two wings, six legs, and a proboscis or long, sharp sucking organ with which it can pierce the human skin.

The anopheles mosquito lives on blood, and this it obtains by settling on some part of the human body and piercing a blood vessel with its proboscis. The insect rests generally during the day, but becomes active about twilight. It may, however, do its evil work in the day-time once it gets inside houses.

A Great War in the Blood

Now let us see the connection of the anopheles mosquito with malaria. The malaria parasite, which belongs to the lowly class of animals known as sporozoa, a name which means seed animals, lives inside the mosquito. When that insect pierces the human skin in order to suck blood, it leaves in the blood of its victim one or more spores of the parasite, which enter the human body with a drop of saliva from the mosquito. Immediately a spore, a kind of egg, enters or attaches itself to a red corpuscle in the blood it at once begins to grow and develop, changing its form a good deal as it does so First it is something like a ring, then it gets irregular in shape, and all the time it is increasing in size until in about forty hours the nucleus divides into a number of fragments. There may be as few as ten or as many as thirty-two. Then the rest of the body divides up into parts, each one of which surrounds a fragment of the nucleus.

These parts have now become a heap of little spores, and soon they burst out of the corpuscle and begin attacking other corpuscles which had no malaria germs or parasites. There they at once repeat the story of the spore that first entered the corpuscle, and so rapid is their multiplication in the blood of the victim that within a day or two he may have as many as three million million malaria parasites in his blood.

Dr. Asa Chandler, who has written about malaria says that a better conception of the real meaning of such a number may perhaps be gained when it is realised that to count off this number at the rate of a hundred per minute day and night without cessation would require thirty times the period that has elapsed since the birth of Jesus.

Now all the time that the parasite has been growing and multiplying in the human victim, it has been living upon the hæmoglobin in the red blood corpuscles. Hæmoglobin is the colouring matter of these corpuscles and is the substance which helps the blood to take up oxygen, as it passes through the lungs, and convey it to all parts of the body. It really enables the blood to be the great oxygen carrier of the body. We can understand, therefore, how serious it is when this substance is consumed by the malaria parasite.

From the Victim Back to the Insect

The red corpuscles, which largely lose their colour, causing the malaria patient to have a sallow skin, become more and more useless until eventually the parasite kills its victim, or at any rate so undermines his health that he loses strength and vitality. But we have not yet finished the remarkable life-story of the malaria germ. It goes on developing, in the manner described, in the blood of its victim for two or three weeks, that is as long as the condition of the blood provides a suitable sphere of environment. But when this, owing to the disease, ceases to be suitable for the normal multiplication, the germs then begin to produce offspring of a different form. They are sausage-shaped crescents, some being males, and others females. They live on in the blood for several weeks, but when an anopheles mosquito pierces the skin of the human victim whose blood contains these male and female germs, some of them are sucked up through the proboscis and enter the mosquito's stomach. Here they change. The male germ develops a number of slender filaments which move to and fro rapidly, and at last break loose and wriggle about in the stomach of the mosquito. Sooner or later they meet and enter one of the female germs, which thus becomes fertilised, as a flower does with pollen, and the result is a new generation of malaria germs, different in form from the ordinary ones.

The new germ resulting from the male and female spores is something like a little worm, and it wriggles about and at last penetrates the inner wall of the mosquito's stomach and lodges between the inner and outer linings. There it begins to develop rapidly. A heavy capsule grows and juts out on the other side of the mosquito's stomach something like a wart, and then the contents of the capsule divide up into a number of spindle-shaped bodies which are new spores. Each capsule contains about 10,000 spores and there may be as many as 500 capsules on a single mosquito's stomach, so that altogether there are about five million spores.

After about a fortnight the capsule bursts and the spores are released. They make their way to the saliva glands of the mosquito, and next time it alights on a human being and pierces his skin some of the spores are left in his blood and the whole process that has been described goes on again. It will be seen, therefore, how difficult it is in a malaria district where the anopheles lives and thrives for any human being to escape malaria.

Getting Rid of Malaria

But the discovery of the life-story of the malaria germ has helped us to get rid of malaria. All that we have to do is to drain the swamps and cover the puddles with oil so that the anopheles cannot live and thrive, and then, of course, the malaria germ also is unable to live.

This is what was done in the Panama zone and what is being done in many other districts formerly notorious for malaria. Boys and girls, including scouts, are being pressed into the service to hunt out the haunts of the anopheles and exterminate the pest. The whole thing is a great triumph of human ingenuity and patient perseverance.

HOW THE SCALLOP TRAVELS THROUGH THE WATER

When we look at the scallop, the well-known mollusc that has a shell consisting of two valves hinged at the narrow end, we may well wonder how it manages to travel in the sea. It has no legs or feelers which enable it to pull itself over the ground or swim through the water.

Nevertheless it manages to move, and it does this by an ingenious arrangement which is on the same principle as the motor-car driven by rockets, which explode at the back of the car and drive it forward.

The two movements which enable the scallop to travel

The scallop when it wants to move opens its two valves and then brings them together suddenly. This causes a rapid stream of water, which by its reaction drives the shell forward as shown in the picture here. Then when the movement is spent the scallop opens its valves once more and snaps them together again for another stroke, and so it progresses.

LIFE ON THE EARTH FOUR MILLION YEARS AGO

In the Cretaceous Period, about four million years ago, there were still great dinosaurs living on the Earth, but the supremacy of the reptile was on the decline. One of the most notable was the triceratops, seen here with two large horns on the forehead and a smaller one on the snout, hence its name, meaning three-horned. There were also iguanodons, one being shown with its head and forepart raised, and another dinosaur was the polacanthus, whose back was protected by a double row of plates. Great flying dragons flew in the air, and toothed birds, which spent much of their time in the water, were common. Mammals had made little progress

THE WONDERFUL NUT THAT RIPENS UNDERGROUND

PEOPLE are inclined to laugh at boys when they see them eating monkey-nuts with a good deal of relish. But the boys are right, for the monkey-nut, called the pea-nut in America, and also the ground-nut, is one of the most valuable of food and oil plants.

It is a member of the leguminous family, to which the pea, bean and lentil belong, and apart from its value as food the plant is of the greatest use to the farmer, for like the other members of its family it helps to fix the nitrogen of the air in the soil, thereby enriching the earth and enabling it to produce better and bigger crops of other plants.

The monkey-nut is a native of South America and the West Indies, but it is now grown in many other parts of the world, including North America, Europe, Africa and Asia.

Curious Form of Ripening

The curious thing about this plant is the way in which it ripens the nuts that are so popular. When the plant grows up it produces leaves which are broken up into four oval leaflets and then the orange-yellow flowers appear, in form very much like those of our own pea plants. After these have been fertilised the flower stalks begin to lengthen, and then they curve down towards the ground and bury the fruit or nuts in the soil.

There the nuts develop fully, and at last become the wrinkled pods, each containing two seeds, which we know so well. If the stalk bearing the young pod does not get buried, the seed withers and does not develop into a nut at all. It is a strange habit.

When the autumn comes, although

How the monkey-nut grows, with its seed pods ripening underground

the upper part of the plant is still flowering, the harvest is gathered, for these late flowers produce only very small nuts and if the plant is allowed to remain so as to develop these, it has a chance of being completely ruined by an early frost.

A furrow is ploughed on each side of the row of plants, and these are then lifted up with forks and the soil shaken off the clustered nuts which are massed among the roots and stems as shown in the photograph on this page. The nuts always face inward, and so are protected by the top of the plant. The nuts are then dried and are picked out by hand or threshed out by machinery.

Valuable for Food and Oil

It is not only as food that the nuts are valuable. They are also a fruitful source of oil. This is pressed from them and is used not only as a substitute for olive oil and for burning, but for lubricating watches and other delicate machinery.

To show the enormous extent to which the pea-nut or ground-nut is now cultivated and used it may be mentioned that in one year alone British India exports over a thousand million pounds of nuts, Senegal about a thousand million pounds and China 530 million pounds. France imports over 1,500 million pounds of nuts a year.

The leaves are also valuable as a fodder plant, being much like clover.

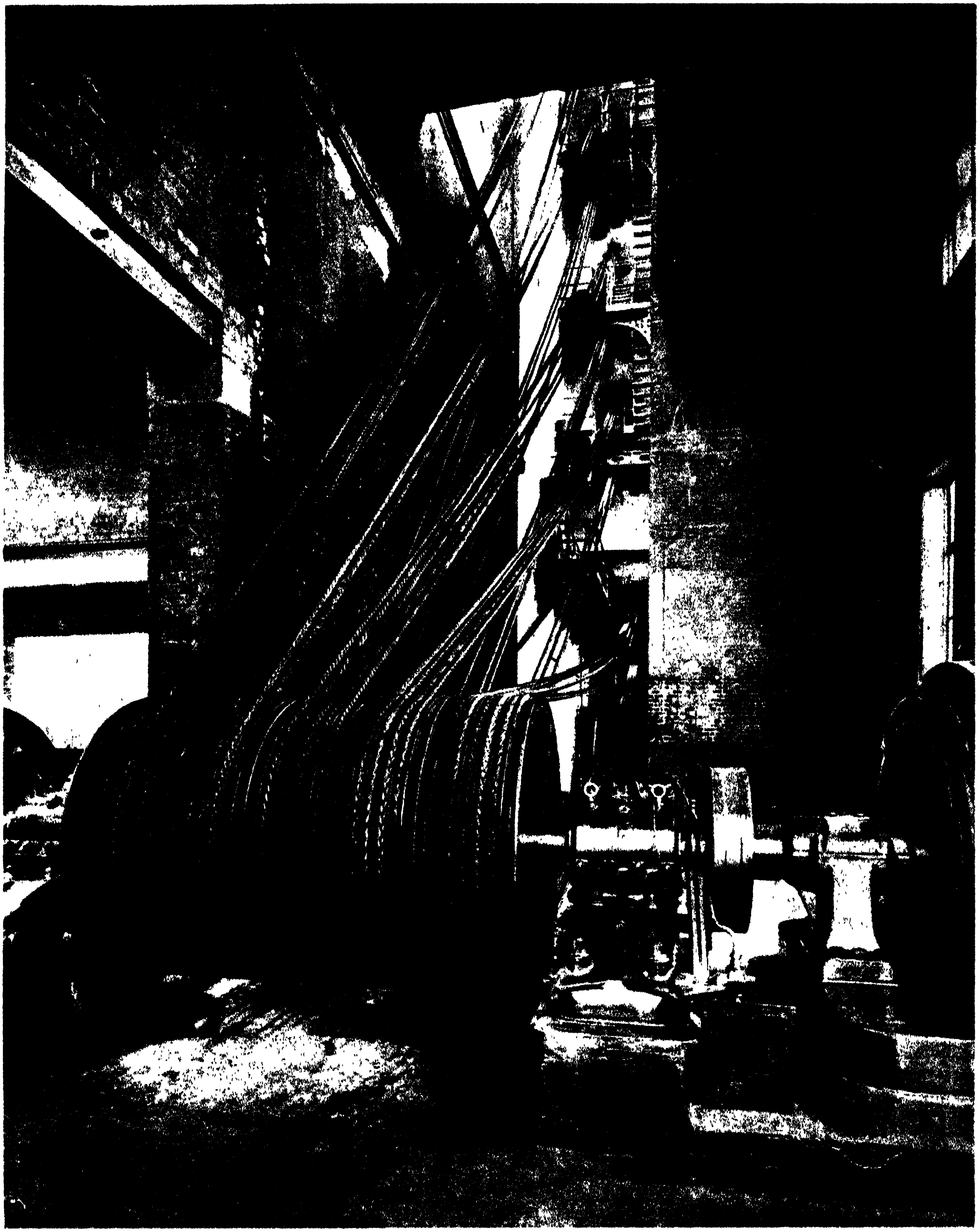
A ground-nut plant as it appears when dug up with a fork. The nuts are now ripe, and after being dried will be picked for use. The plant is a native of South America, but nowadays thousands of millions of pounds of nuts are produced in other parts of the world

THE AFRICAN ELEPHANT AND ITS IVORY

The African elephant, which supplies most of the ivory that comes into the world's markets, was in danger of extermination a few years ago. Over 40,000 were being slain for their ivory every year. In recent years, however, the animal has been protected by various governments and as a result the animal is now again multiplying rapidly. This fine photograph shows a group of African elephants in their native haunts. The African animal's tusks are larger and the ivory finer than those of the Indian elephant

Here we see a warehouse at the London Docks with a big consignment of elephants' tusks that has just arrived. Some of these are from Africa and others from India and Siam. Tusks weigh from 16 pounds to 150 pounds each. The hardest ivory from West Africa is used for knife handles, hair brushes, and such articles. Billiard balls are made from the smaller tusks. Ivory does not deteriorate with age, nor is it spoilt by water. African ivory takes a finer polish than Asiatic and it keeps its white colour better

HOW POWER IS CONVEYED BY ROPE BELTS



In many factories the power produced by the engine is transmitted to the different floors by rope belting, as shown in this striking photograph. There are many advantages in using ropes instead of leather belts for the transmission of power. Ropes take up less room, they are much cheaper where the power has to be carried to a considerable distance, they do not slip to the same extent as leather, and they do not need to be exactly in line with the shafts they turn. The ropes work in V-grooved rims, the bottom of the grooves being round and the sides smooth to prevent wear. On a great drum all the grooves must be of the same diameters and angles

A MIGHTY RAM TO SMASH JACK FROST

Man no longer fears the power of the ice in the cold seas of the world. He is now able to build powerful vessels of the hardest steel that can resist the relentless pressure of the ice, and when driven by high-powered engines can, by means of a massive ram in front, smash a way through. Such vessels are known as icebreakers, and here we read something about them and how they were first given to the world by British engineering

IN the old days of wooden ships these vessels were at the mercy of Jack Frost. Many a good ship has gone north to the regions of ice and snow and been made a prisoner as the ice closed round it. Then later it has been crushed by the pressure of the ice and left a wreck.

Nowadays, however, there are ships specially designed with strengthened hulls and bows for navigating in ice-bound seas.

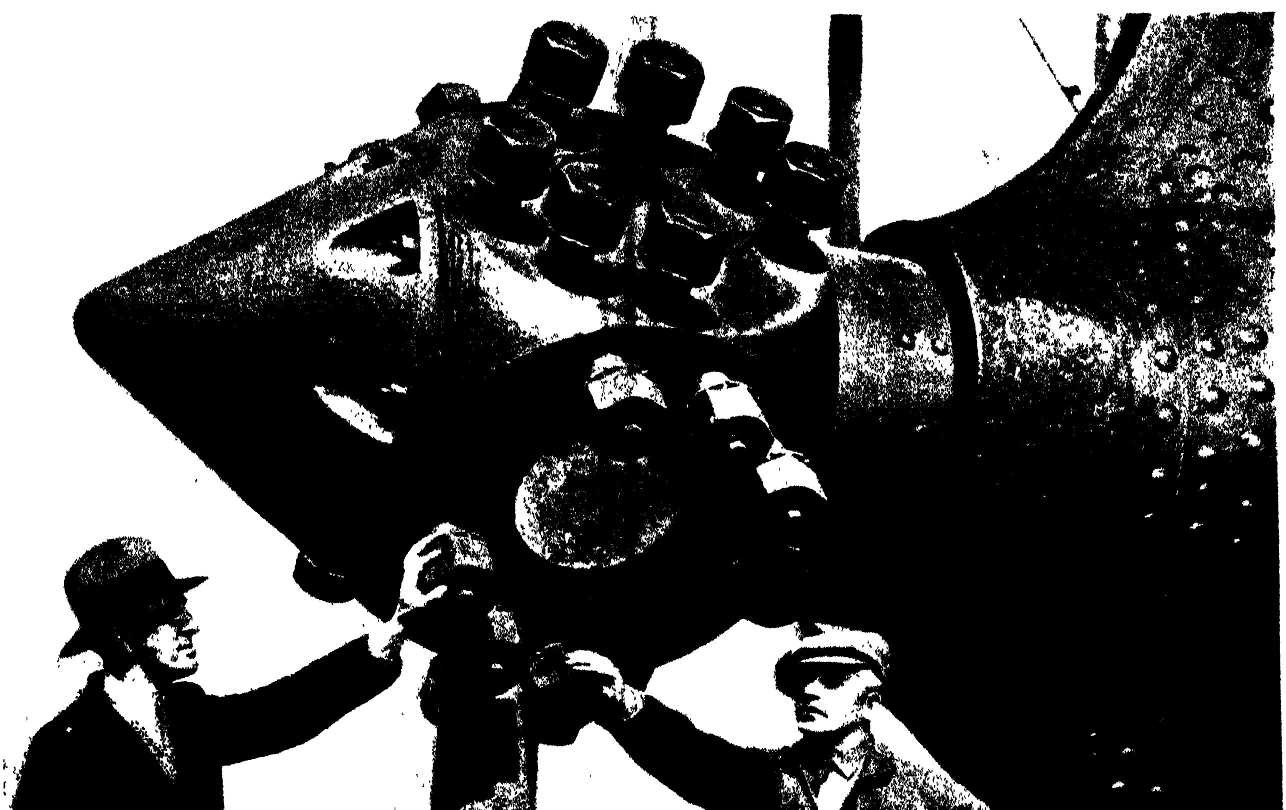
It was the British who first began building ice-breaking vessels, ships made of the strongest steel and so constructed with powerful rams in front that they could smash a way through the ice. The first vessel of this type was the *Baikal*, built at Newcastle-on-Tyne for the Russian Government. It was intended as a train ferry, to carry the trains of the Siberian Railway across Lake Baikal when the lake was frost-bound.

The ship had three powerful engines, two being placed aft, that is, in the hind part of the vessel, and one forward. The forward engine was to drive a screw in front, which should turn rapidly and disturb the water, thereby weakening the ice, and enabling the enormous weight of the vessel as it pressed forward to smash up the ice and make a path for itself.

The vessel was driven forward by two powerful propellers behind. All the propellers were made of cast steel, the forward one being protected from the ice under an overhanging stem.

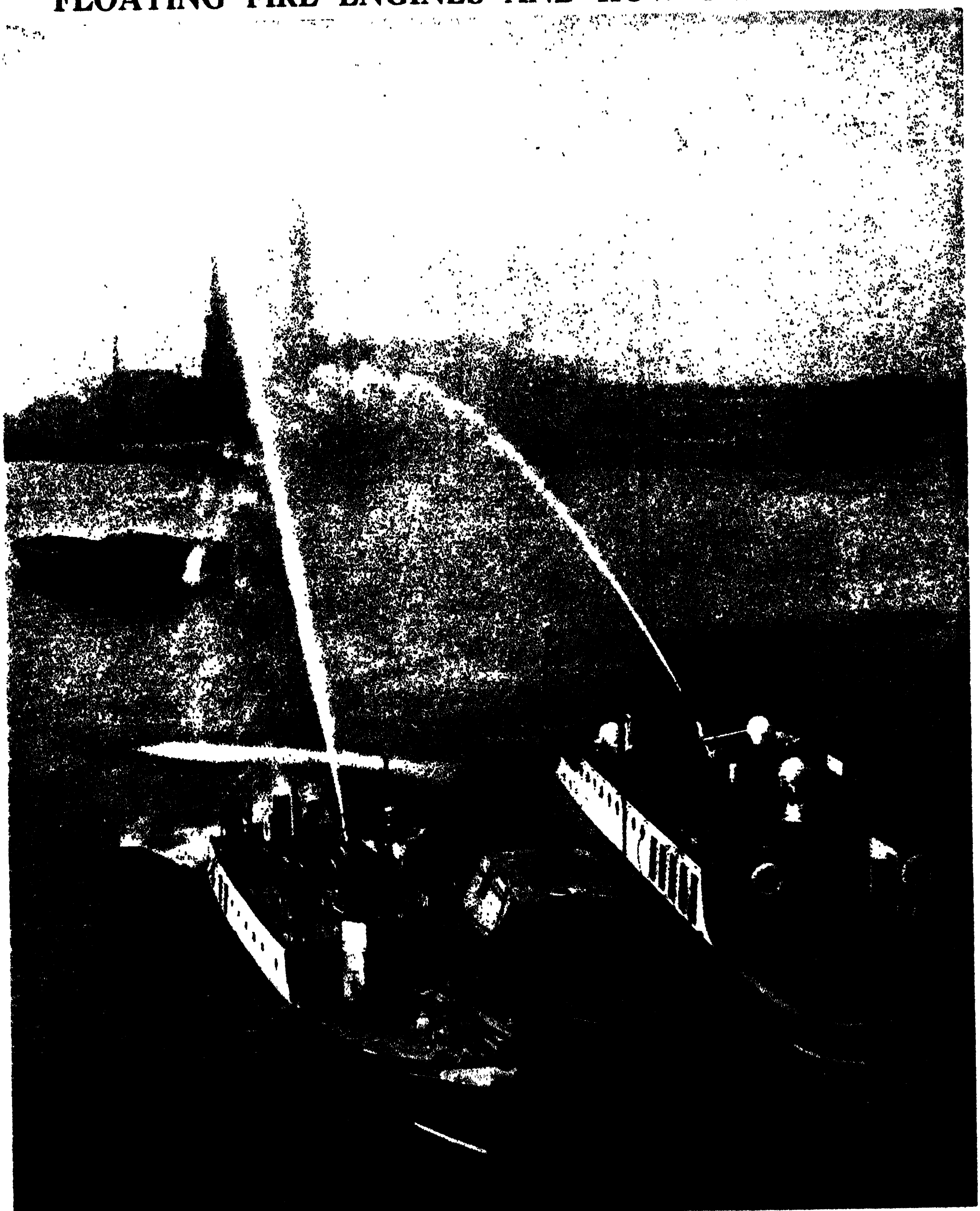
The *Baikal* was a tremendous success, and since then other ice-breaking vessels have been built in England. Another one built for the Russian Government was the *Ermack*. This vessel had three screws behind and one at the fore end. She did good work and was then returned to the Tyne to have her length increased by 15 feet. When she was enlarged the forward screw was omitted.

One of the largest ice-breakers is the *Charlottetown*, built in a Canadian shipyard for the Canadian National Railways. She is for the ferry service between Prince Edward Island and the mainland of New Brunswick. She has an enormous ram, and her propeller blades are bolted separately to the shafts, so that if by misfortune one of them should be smashed as she ploughs her way through the ice, it can be replaced more easily and cheaply than if the whole propeller were smashed. Extra blades are carried on board, so that in case of accident they can be fixed without returning to port.



The "nose" of the icebreaker *Charlottetown*, built as a railway ferry between Prince Edward Island and the mainland of Canada for the Canadian National Railways. To it separate propeller blades will be bolted with the giant bolts and nuts seen in the photograph

FLOATING FIRE ENGINES AND HOW THEY WORK

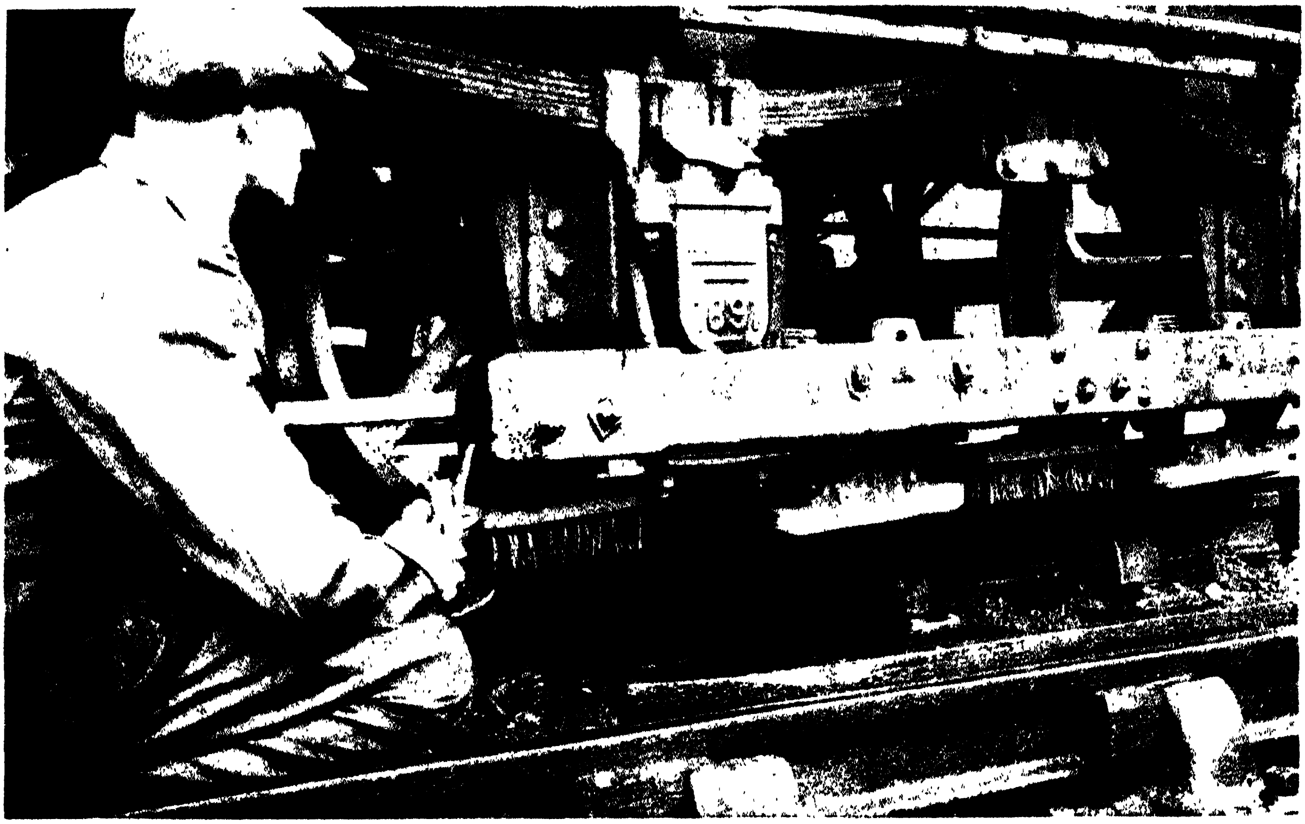


The method of fighting fire in large cities has been brought to a high state of efficiency, and some wonderful appliances are now in use. For extinguishing fires along the waterside in London, for example, there are three powerful motor floats and one steam float. These are really powerful floating fire engines and can direct huge streams of water at high pressure upon a burning building. New York has ten floating engines. Such craft are essential in cities like London and New York where there are large warehouses and other buildings along the waterside, which could not be approached by land engines. In New York the losses due to fires are between £3,000,000 and £4,000,000 a year, and in London about £700,000. Here we see London floats at practice

LONDON FIREMEN BATTLING WITH THE FLAMES

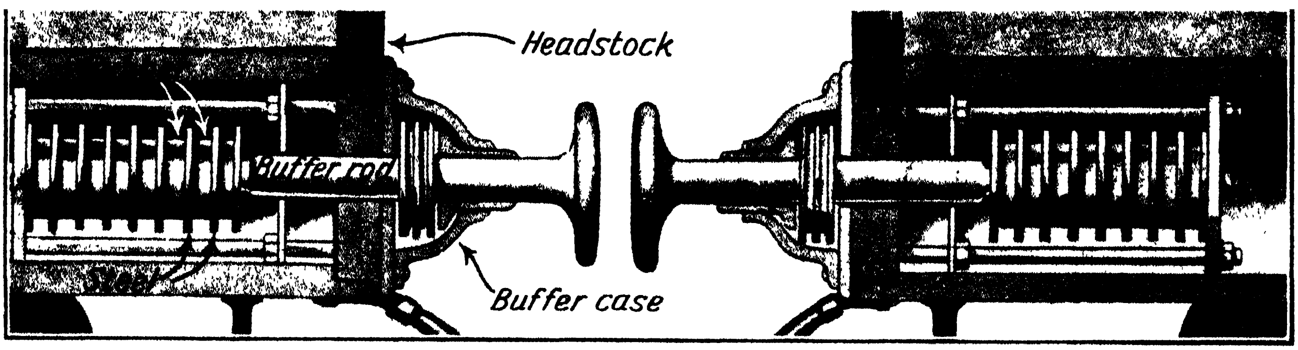
As buildings have been made higher and higher so fire-fighting appliances have had to be extended and made more powerful. The pumps of motor fire engines, such as the one illustrated in page 704, can throw water at very great pressure to a height of over 100 feet. Turntable ladders (one is illustrated in pages 1300–1) can be used as water towers for pouring a stream of water down upon a burning building, and such a fire ladder can be fully raised and arranged in any position by one man in less than a minute. Here we see firemen battling with the flames by means of fire-ladders up which the hose carries the water. The London Fire Brigade uses over 63,000 tons of water a year. The greatest fire of all time was at Chicago in 1871, when the damage amounted to £39,000,000.

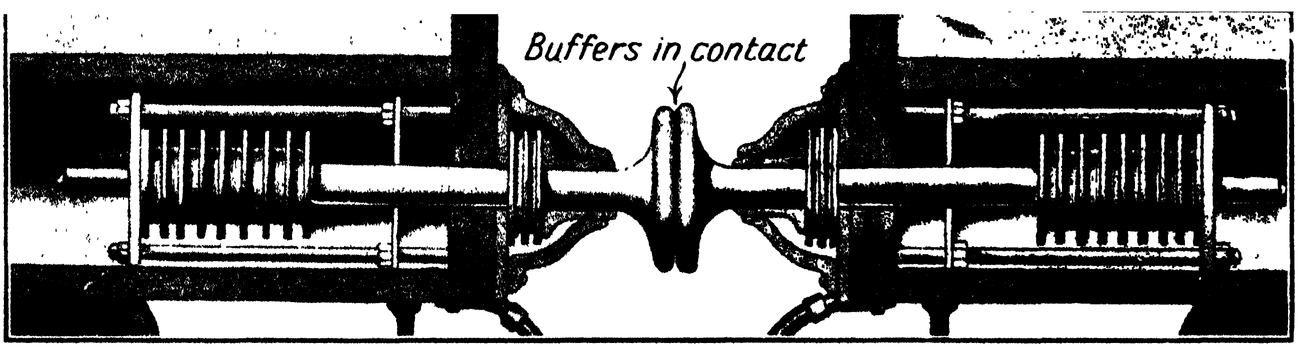
THE SNOW-SWEEPER OF THE ELECTRIC RAILWAY



When there is likely to be snow, the electric railways keep a special train standing by for clearing the snow from the live rail. The locomotive is fitted with brushes on either side of the pick-up shoe as shown in the photograph, and as it moves along it sweeps the snow from the rail while a small squeegee behind each brush wipes the rail dry. Conductor rails must be kept dry to prevent short-circuiting.

HOW THE BUFFERS OF A RAILWAY CARRIAGE WORK





These pictures show what the buffers of the railway train are like inside. In the older form of buffer steel springs were used, but nowadays rubber has largely taken the place of steel. There are rings or blocks of rubber alternating with plates of steel, and when the carriages come together the rubber absorbs the shock, becoming compressed and offering greater resistance as the movement increases. In order to provide against a shock of extra severity, the buffers have outside the headstock an additional spring which comes into play before the main springs are forced right home. In the buffers of engines springs made of steel of very high quality are used instead of rubber

MARVELS of CHEMISTRY & PHYSICS

BRINGING LIGHTNING FROM THE SKIES

All our big buildings have lightning conductors, that is, spiky rods erected above their highest points. These are very necessary if the buildings that stand high above surrounding objects are not to be struck by lightning in severe storms. In these pages we read how the lightning conductor was invented, and how one of the very first was fixed on St. Paul's Cathedral

LIGHTNING was a great mystery to the people of ancient times They thought it was the thunderbolts of the gods, and they divided it up into various kinds. There was individual lightning and family lightning and explanatory lightning and perfidious lightning, and so on.

These ideas were, of course, all due to their ignorance of natural laws Every phenomenon of Nature was attributed to the action of the gods, some being beneficent and useful to man and others being malevolent and dangerous.

We now know the cause of lightning, and that there are three kinds, known respectively as fork lightning, sheet lightning and globe lightning We read about these in another part of this book (page 281), but it is worth while seeing how men came to find out what lightning really was

Men had found that by rubbing amber and glass rods with silk they could produce curious effects, including sparks, and it was suggested that these sparks, with their crackling noise, were something like lightning and thunder on a small scale

Early Experiments

It was an American, Benjamin Franklin, who was born a British subject, though after the War of Independence he became a citizen of the United States, who first suggested that this theory should be put to the test and proved or disproved by experiment.

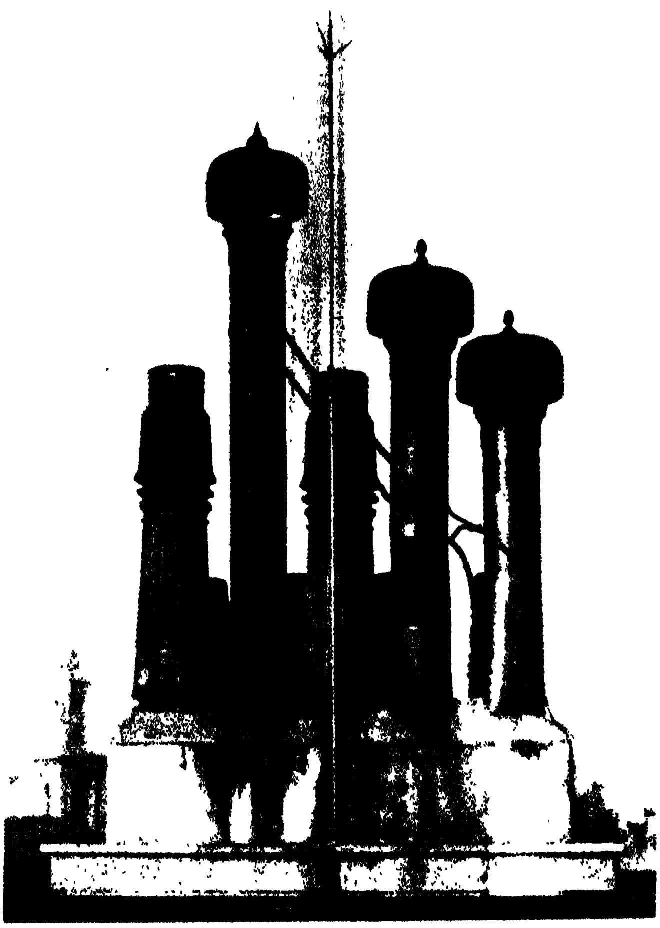
Franklin, however, was not the first man to carry out the experiment. A French philosopher named Thomas Dalibar, learning of Franklin's suggestion, put up in a garden at Marly, several insulated iron rods with points at the top, in order to catch the lightning. Sure enough, when a thunderstorm passed over, from one of the iron points, which was 46 feet above the ground, he drew an electric spark a foot long, and charged a number of Leyden jars. He knew that the spark was due to the lightning, for a thunder clap followed almost immediately

This was on May 10th, 1752, and a month later in America Benjamin Franklin carried out a still more striking experiment on the same lines. During a thunderstorm he sent up a kite made of silk, on the top of which was fixed a piece of thin wire. At the end of the string which held the kite he fastened a silk ribbon and at the place where the string and the ribbon were tied together he hung a door-key. It was a risky experiment, but men of science are brave, and take great risks in order to add to human knowledge For a time nothing happened, but presently Franklin, watching his string, noticed that the short loose strands of the material stood out stiffly at right angles

Then he touched the key and at once felt an electric shock and saw a spark As the string was wetted with the falling rain it became a better conductor, and Franklin was able to collect the electricity from the key by means of a Leyden jar He had proved beyond the shadow of a doubt that electricity and lightning were identical. A picture of his experiment is given on page 290.

The next year another French philosopher, De Romas, repeated the experiment with better apparatus. He used a cord for his kite in which a wire was interwoven with the hemp, and he used a larger kite, one 7 feet high and 3 feet wide, with a total surface of 18 square feet. By having a dry silk cord at the end of the hempen cord he made his kite much more effective than Franklin's. He also fastened a tin tube to the string of the kite about 3 feet from the ground.

Sending up his kite into the clouds in apparently fine weather he made a discovery, for he found that he could obtain electricity when there was no storm and no thunder and lightning to be seen or heard



The lightning conductor which guards the Editor's office at The Fleetway House, London, from thunderstorms

The Dance of the Straws

Looking at the tin tube fastened to the string of the kite he noticed three straws all standing erect and performing a kind of dance, like puppets in the tin tube, without touching one another. This little entertainment lasted about a quarter of an hour, and then some drops of rain began to fall.

De Romas felt a sensation on his face as though it were covered with a cobweb, and at the same time he heard a rustling noise which he describes as "like that of a small forge bellows." Still there was no lightning or thunder, but it became clear that he was drawing electricity from

the clouds, and that the quantity was increasing. He therefore decided to be more careful and asked a number of friends who were watching the experiment to spread themselves round to a greater distance.

Then occurred something which De Romas acknowledges made him tremble. The longest straw was attracted by the tin tube and there followed three loud sounds, greatly resembling thunder. Some of the company likened them to the explosion of rockets, and others to the crashing of large earthen jars against a pavement. The sounds were heard in the adjoining city.

At the moment of the noises a fire was seen shaped like a spindle 8 inches long and half an inch in diameter. The straw which had caused the explosion was now attracted along the string, being alternately attracted and repelled, and every time it was attracted by the string flashes of fire were seen and cracks heard. All this time no lightning was seen and there was scarcely any thunder, but a smell of sulphur was noticed.

When the experiment was over, a hole was discovered in the ground, perpendicularly under the tin tube, an inch deep and half an inch wide, which had evidently been made by the flashes accompanying the explosive sounds.

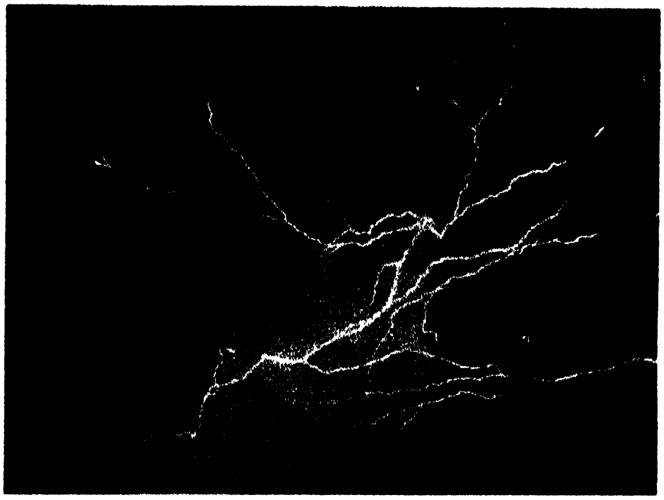
Electric Shocks

The experiment was brought to an end by the kite falling. The string fell across a small outhouse, but the moment it was disengaged the person holding it felt a shock in his hands and a commotion through his whole body, which obliged him instantly to let go. The string falling on the feet of some other people near by gave them an electric shock, though not a severe one.

Men, after centuries of wonder, were learning by experiment a great deal about the lightning. Franklin continued his experiments with a kite and found that some clouds are charged with positive and some with negative electricity. Then he reasoned that if lightning could be brought from the skies down the string of his kite or down a pointed metal rod, it should be possible to make a safe route for the lightning from the clouds into the ground, so as to protect buildings from being struck and damaged.

If, said he, a rod of iron made as sharp as a needle were fixed to the highest point of a building and carried down into the earth the lightning would strike the point and pass down the metal without harming the building.

Thus he invented the lightning conductor, which is now fixed to all important buildings. One of the first was fixed to St. Paul's Cathedral, the Dean and Chapter having been greatly alarmed by the fact that St. Bride's Church in Fleet Street, not far away, had been struck by lightning and seriously damaged. They were advised by the Royal Society to "make a complete metallic communication between the cross placed over the lanthorn and the leaden covering of the great dome."



Lightning flashes passing between cloud and cloud

Lightning flashes passing from cloud to Earth

This was done in 1769, and the existing water pipes were used as conductors from the roof to the ground. A year or two later the Royal Society advised the Government to have pointed conductors placed in position for the protection from lightning of the gunpowder magazine at Purfleet in Essex.

Then began a great dispute among scientists as to whether points or knobs were better for catching the lightning. When, despite the pointed conductor at Purfleet, the magazine was struck by lightning in 1777, though no explosion occurred, the advocates of the knobs thought they had won the day. A Committee of the Royal Society, however, reported in favour of points, and then the propounder of the knob theory became very angry.

He asked all patriotic Englishmen to support the party of the knobs, because the inventor of the pointed conductor was Benjamin Franklin, a rebel then waging war with King George's troops in the American Colonies.

The public took up the quarrel, and it is said that George III actually tried to make the Royal Society revoke its resolution in favour of points. He had an interview with the President, Sir John Pringle, who refused, declaring "My duty, sire, as well as my inclination, will always induce me to execute your Majesty's wishes, but I cannot reverse the laws and operations of Nature."

After the War of Independence the political aspect of the quarrel disappeared, and the party of the points won. Men had now found out not only the nature of lightning but a means of protecting their buildings from its unexpected attacks.

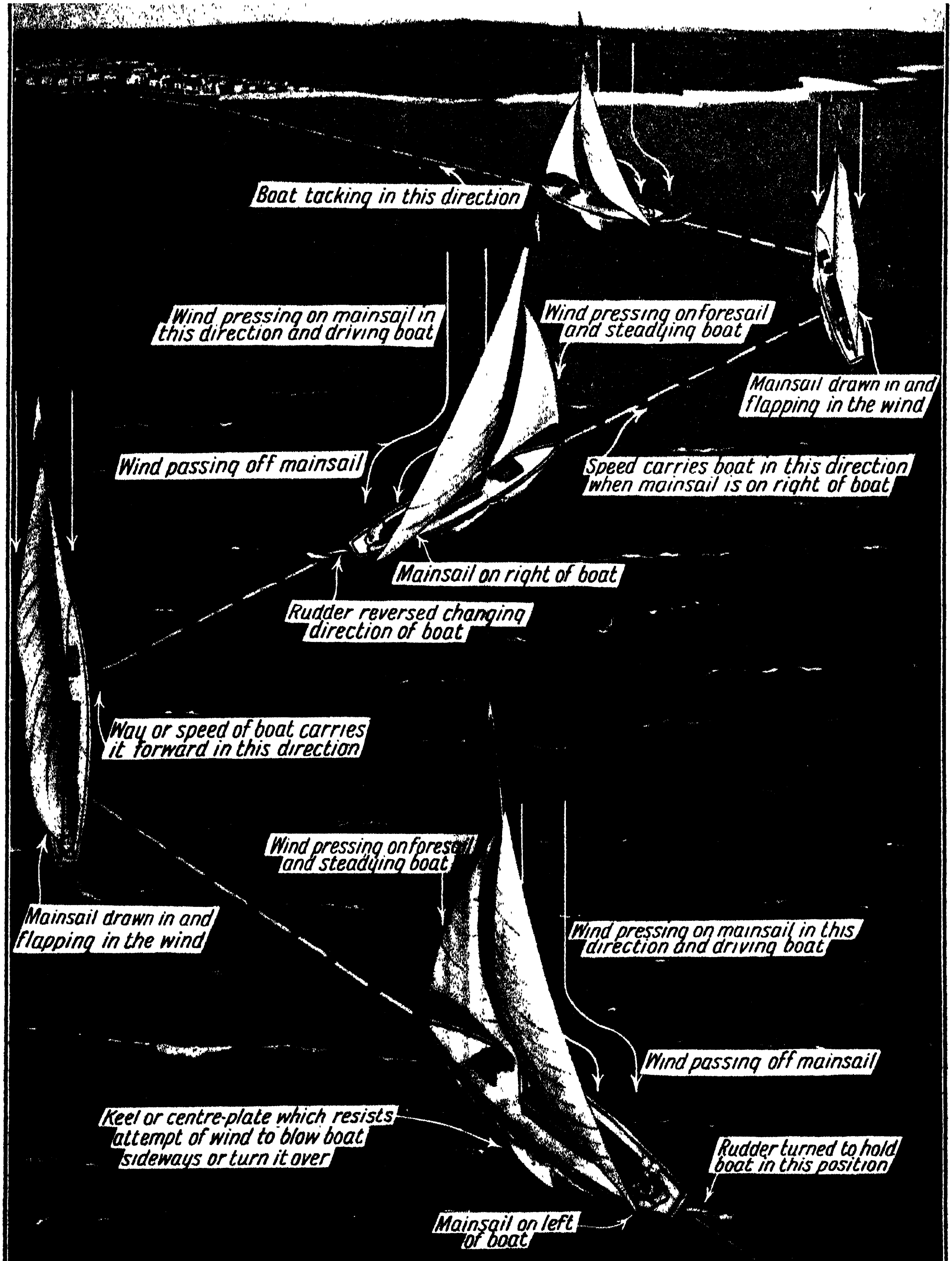
Strange Opposition

It seems curious that there should have been for a long time a great popular opposition to the erection of ligh ning conductors. Many ignorant people, hearing that the conductors were to lead the lightning down into the earth, feared that some evil result would happen, and were very hostile to their erection.

Then there were fanatics who opposed the erection of lightning conductors on religious grounds. They said it would remove one of the instruments of heaven for punishing sinful mortals.

In France there was opposition of a different and even stranger kind. The Abbé Nollet, a Frenchman, had come to be looked upon as the greatest of living electrical scientists, and when Franklin by his discoveries received general homage in all countries, the self-esteem of the French was roused. The Abbé himself became fiercely irritated that a foreigner should snatch from him his laurels, and so he used all his influence at the French court to depreciate Franklin's invention and denounce it as an imposture. He declared it was dangerous and for a long time conductors were not used in France.

HOW A BOAT SAILS AGAINST THE WIND



This picture explains how it is that a boat can sail against the wind. In the ordinary way the wind would blow a sailing boat before it, but by moving the sail and rudder as shown the boat is able to sail in a slanting direction across the wind. The boat sails first in one direction then in another, and by taking a zigzag course reaches its destination. This is called "tacking." The pressure of the water against the keel, or centre-plate, of the boat prevents the wind from blowing the craft over or driving it sideways. The wind, of course, wants to clear everything from its path. When it hits the sails of the boat it cannot get through, and so, as they are aslant, it glides off them and then continues its course, as shown in the picture. As the wind strikes the sails it pushes the boat, which moves along the line of least resistance. If the sails were fixed in line with the deck the boat would be blown over in a strong wind

THE STRANGE MYSTERY OF THE BOOMERANG

The boomerang is probably the most curious of all weapons, and the Australian natives are remarkably skilful in throwing it. They can throw it in all sorts of ways so that it will make various curves and turns in the air, travel three hundred feet and return to where the thrower is standing.

This curious behaviour is due to the shape of the boomerang. It is curved so that one edge is convex and the other concave, but the curve varies a great deal, the boomerang being sometimes only slightly curved, while other specimens are sickle-shaped, or have the two halves almost at right angles.

But the curve is not the only curious thing about the boomerang. It is flat on one side and rounded on the other, and the weapon has also a slight twist or skew through its length, so that the two ends are not on exactly the same level or plane as the middle part.

All these peculiarities give the boomerang, when it is thrown in a certain way, a kind of aeroplane motion. It is held with the convex edge forward and the flat side down, and is then thrown onward with a rapid fling. At once it rises in the air, whirling round and round and forming a curve, and after reaching a height of perhaps 150 feet it begins to return towards the thrower and falls somewhere near him.

Even if it hits a bird or the ground lightly it may return, but there are all sorts of fairy tales told about the boomerang which are not true. For example, it does not return to the hand of the thrower, except perhaps occasionally by chance. Nor can a boomerang be thrown so as to strike an animal or a man hard and then return. Boomerangs used in war and hunting could kill a man or animal, but they would then fall to the ground.

Cardboard boomerangs cut to various shapes out of a post card and the method of propelling them

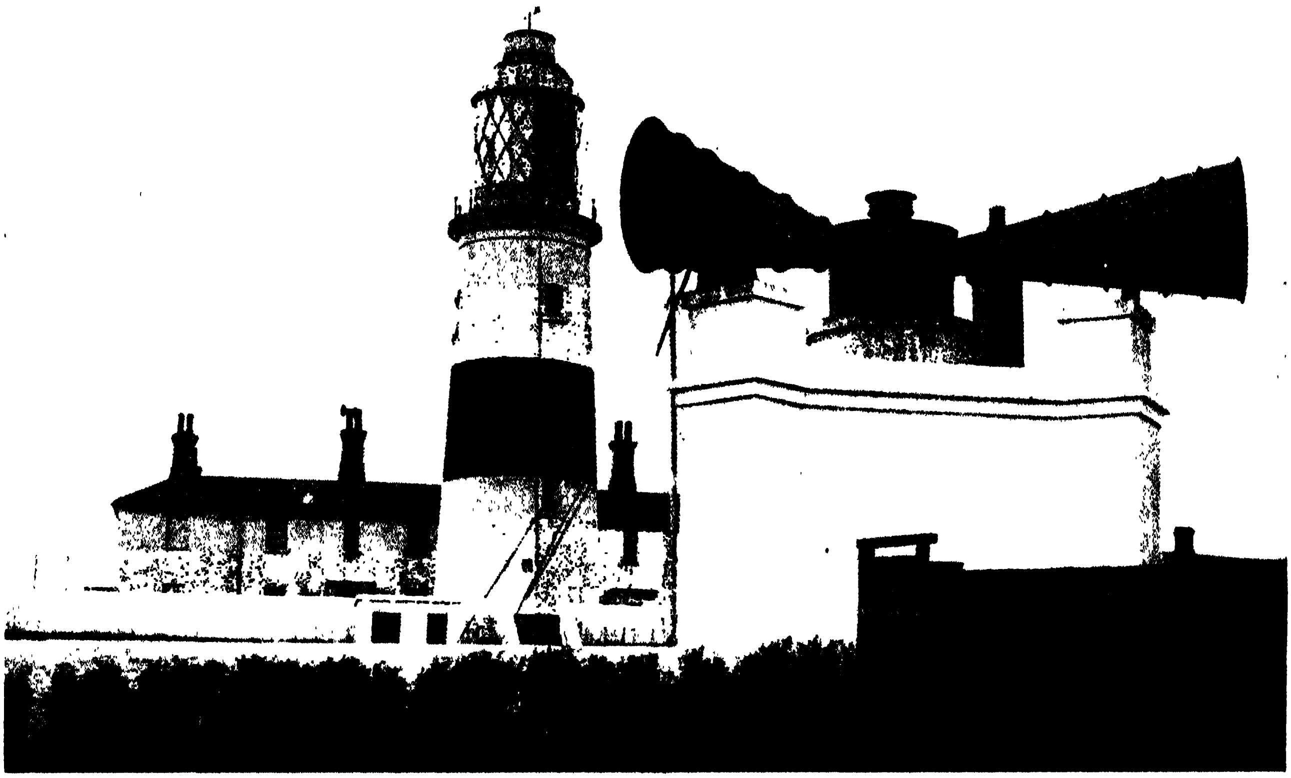
Australian boomerangs are made of hard wood and are from 24 to 30 inches long, but we can make small toy boomerangs of cardboard, cutting them from a post card to any of the shapes shown in the upper picture. When we have made the boomerangs we experiment with them in turn.

Place a boomerang on a book in the manner shown with the convex side facing the direction in which it is to travel, and one arm projecting. Then with a pencil or ruler give a sharp blow. At once the missile flies off and after going across the room turns round and comes back to where we stand.

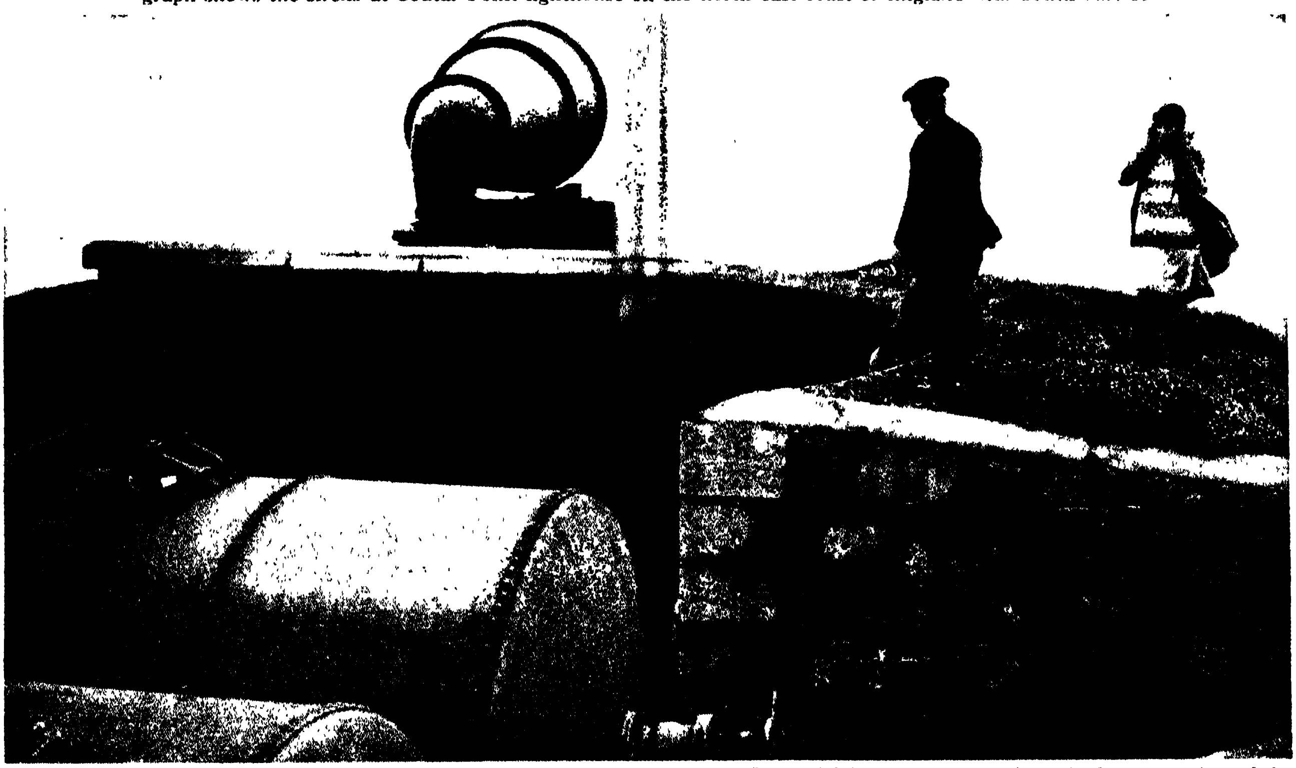
The boomerang, being thrown with the flat side downward, would tend to follow irregular movements just as a piece of paper flutters in the air when thrown. But the movement of rotation given to the boomerang by the thrower checks such irregularities at the beginning of its flight and allows it to follow the course designed by its thrower. When the impetus has lessened the weapon begins to fall, but its shape causes it to slide slantingly down the air towards the thrower. It is surprising that a weapon so scientific should have been perfected by Australian natives.

Two Australian natives holding their boomerangs ready for throwing. The missiles are given a twirling motion as they are hurled forward and their curious shape, together with their rotation, causes them to travel along strange paths in the air

THE GIANT SIRENS THAT WARN THE MARINERS

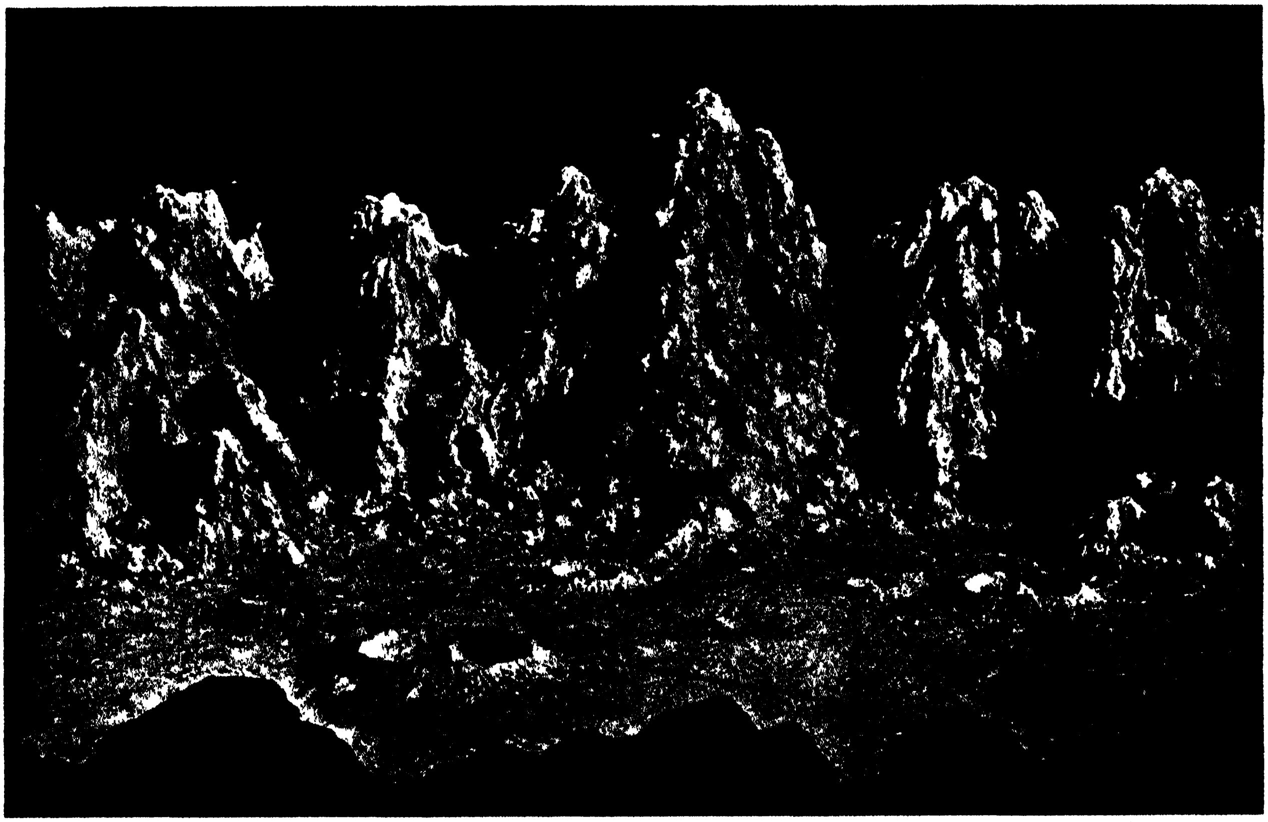


Lighthouses are useless in thick foggy weather as their beams cannot penetrate the mist. In order that ships at sea may be warned of their danger powerful sirens or fog-horns are set working, and these give out a loud sound that can be heard for a great distance By placing two sirens side by side at an angle of about 120 degrees, the sound can be distributed over a very wide area. The photograph shows the sirens at Soutar Point lighthouse on the north-east coast of England near South Shields

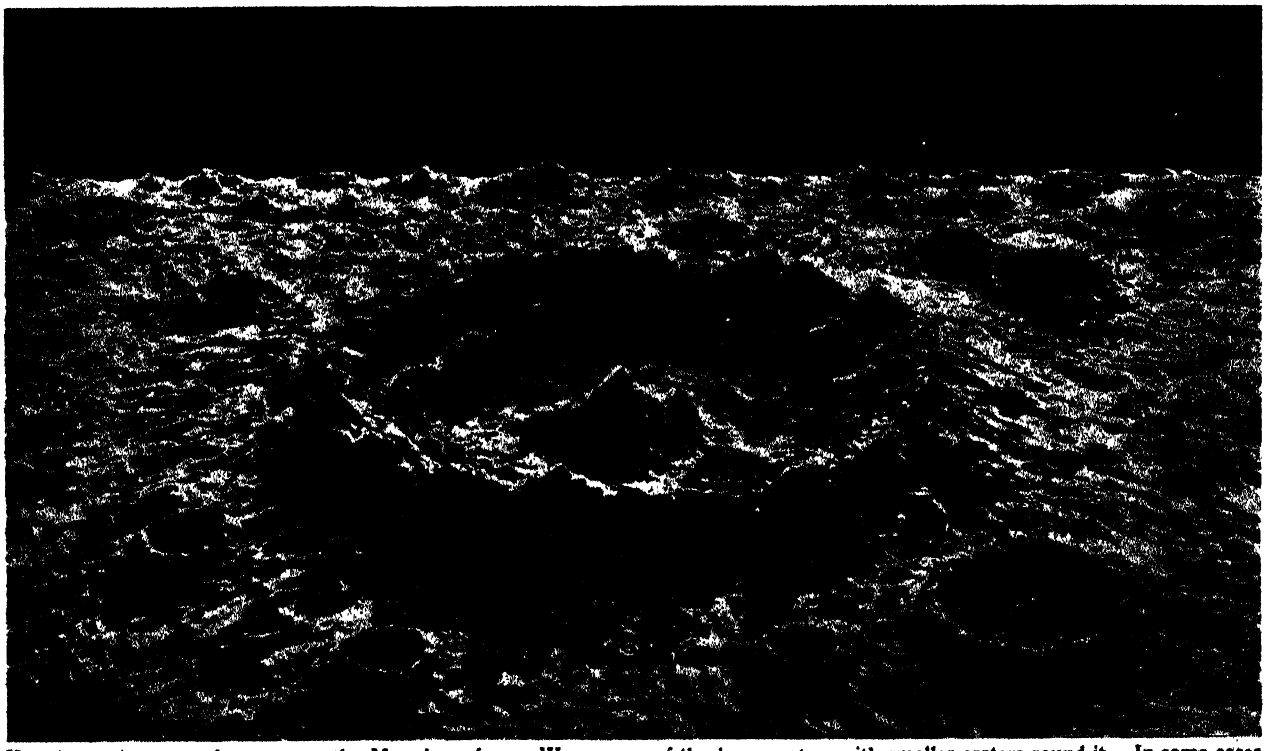


This fog-horn at Fort Doyle, on the north-east extremity of Guernsey in the Channel Islands, warns mariners in foggy weather of the dangers of that coast. Sirens are almost as valuable as warnings as the powerful beams of the lighthouses, and the range or area over which they can be heard is constantly being increased. Until the middle of the nineteenth century fog signals were practically unknown. Then guns and bells came into use. The present powerful sirens known as diaphones are an invention of the twentieth century. The sound is made by a piston working in a cylinder, both of which have slots, and the power is provided by compressed air

THE MOUNTAINS AND CRATERS OF THE MOON



In this picture we see a representation of a group of mountains on the Moon as they would appear in the daytime. The sky would be dark, and the lights and shadows on the Moon's surface would be very distinctive. Only where the Sun shone directly would there be light. There are ten great mountain ranges on the Moon, the peaks being higher in proportion to the Moon's size than are the Earth's mountains Some of these mountains rise 20,000 feet above the plains. On the same scale the Himalayas would be over fifteen miles high



Here is another type of scenery on the Moon's surface. We see one of the huge craters with smaller craters round it. In some cases these craters are over a hundred miles across, and 19,000 feet deep. In the centre of most of them is a mountain, the peak of which rises to a height of 12,000 feet or more. The circular range of mountains surrounding a crater rises sometimes to 20,000 feet above the surrounding plain. We can see in the map on page 16 how huge these craters are compared with England

MEASURING THE MOUNTAINS OF THE MOON

When an astronomer first declared that he had measured the height of a mountain on the Moon he was regarded as a romancer. "How," it was asked, "could anyone measure a mountain on a world so far away?" Well, on this page we learn how the great feat is done, and some of the astounding facts and figures that result from the measurements of the astronomers

It may seem a strange thing to say, but it is nevertheless true that the mountains on the Moon's surface can be measured with much greater accuracy than some of the mountains on the Earth.

How is it possible to measure the height of a mountain on a world that is nearly a quarter of a million miles away? Well, let us see.

Suppose we want to measure the height of a flagstaff. How can we do it? We can find its height by measuring the length of the shadow which it casts upon the ground at noon. Of course, it is not true to say that the height of the flagstaff is the same as the length of its shadow, although this is practically correct if we make our measurement in London on April 6th or September 5th. On those days the shadow cast at noon corresponds in length with the height of the object that causes the shadow. At other times of the year a certain calculation has to be made, which is a little too technical to go into here.

We can carry out a simpler experiment than that of measuring the flagstaff. Suppose we fix a stick upright in the ground so that exactly a yard of it remains above the surface. Now, at a certain time of the day the shadow thrown by the stick when the Sun shines upon it is twice as long as the stick itself

Measuring the Shadows

We gather from this, therefore, that all shadows cast at the same time by upright objects will be twice their height. Knowing this we can measure the height of the church spire or of a tree or of our house by simply measuring the shadow and dividing by two.

Now, just as we can find, with perfect accuracy, the height of an object like a flagstaff or a church from the shadow which it casts upon the ground, so astronomers are able to discover the height of the mountains on the Moon by measuring the length of their shadows as cast on the Moon's surface. These shadows are seen very clearly in telescopes. Their length, of course, increases the lower the Sun sinks towards the Moon's horizon, and they get less the higher the Sun rises above the horizon of that particular lunar region.

Now astronomers can measure exactly the length of the shadow at any particular time, and by finding what proportion this is of the Moon's diameter they can find its length.

The Moon's diameter is 2,163 miles, so that if a shadow is found to be 1-540th of the diameter it is obviously four miles long. Knowing the time of day and the extent to which shadows lengthen on the Moon at that time, all of which can be worked out by mathematics, the astronomer is able by trigonometry to calculate the height of the mountains that cast the shadow, almost exactly.

It is much more difficult to measure with equal accuracy such mountains as Everest or other peaks in the Himalayas and the Andes.

Surprising results have come from the measuring of the Moon's mountains. There are ten mountain ranges on the Moon, and some of the tall and jagged peaks are found to be more than 20,000 feet above the plains on which they stand. Professor Forest Moulton has pointed out that if the mountains on the Earth were on the same scale they would be more than fifteen miles high.

Why is it that these lunar mountains are, in proportion to the Moon's size, so much higher than the Earth's mountains? Well, it is no doubt partly due to the fact that gravitation at the Moon's surface is far less than it is on the Earth's surface, which means that there is not the same pull on loose fragments, and it is partly due to the lack of erosion owing to the Moon having no atmosphere or rain or rivers.

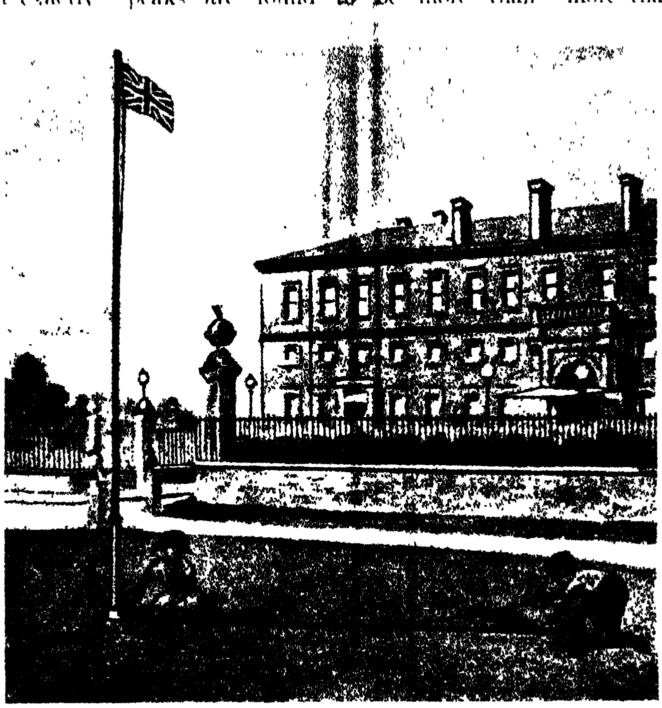
The fact that the Moon has no atmosphere makes it easier to measure the shadows, for these shadows are much clearer and more distinct than mountain shadows on the Earth. Not only can the heights of isolated peaks and mountain ranges on the Moon's surface be measured, but also the heights of the walls surrounding the lunar craters.

These are the most conspicuous objects on the Moon's surface, and more than 30,000 of them have been mapped. In many cases they are over a hundred miles across, and in some cases one hundred and fifty miles, while the rampart round some towers up 13,000 feet above the surrounding plain. In the centre of many of them is an isolated peak which towers up more than 12,000 feet above the floor of the crater, which may be 19,000 feet deep.

The Straight Range

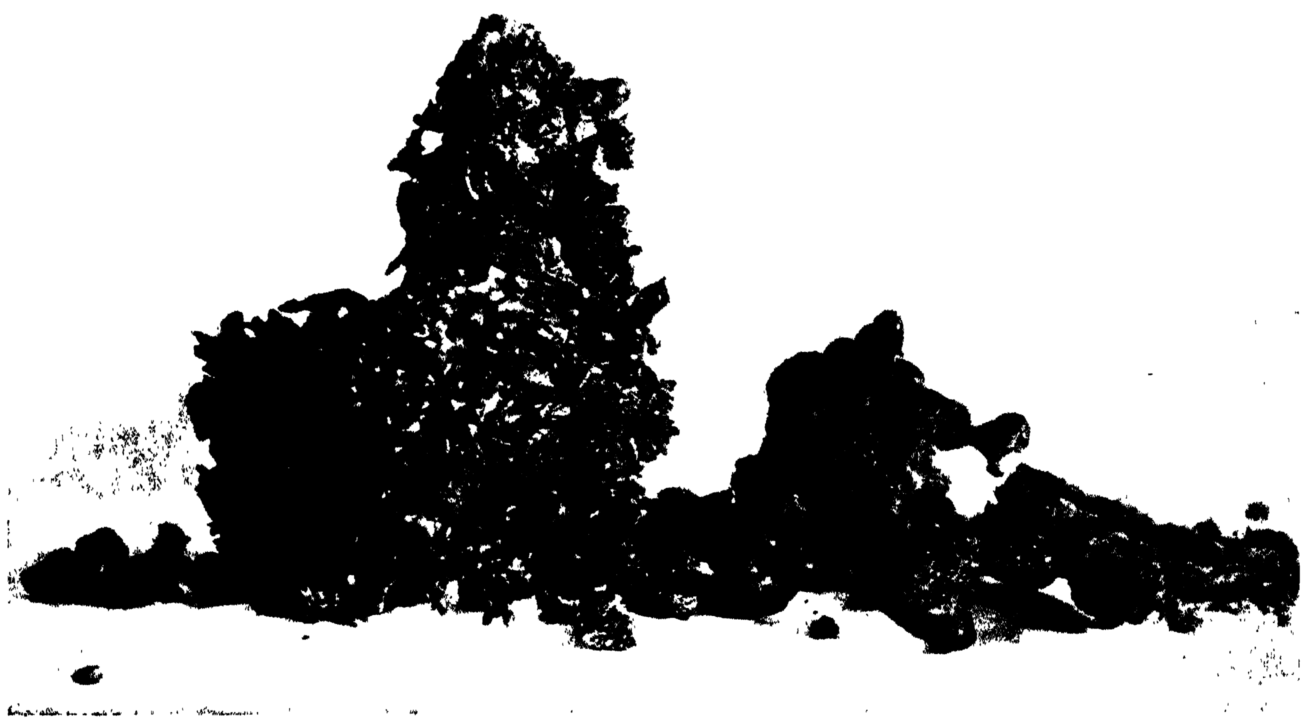
There is one elevation on the Moon's surface which is unlike any of the others. It is known as the Straight Range, and has the appearance of a sword with a hilt. It seems to be due to a fault or cracking across the arena of an old crater, one half of it having sunk down so that there is a difference of about 2,500 feet between the two levels.

All these facts and figures are learned by means of the shadows cast as the Sun shines upon the Moon.



Discovering the height of a flagmast by measuring the length of the shadow which it casts upon the ground

A MASS OF WHITE-HOT IRON FROM THE SKY



Meteorites, which are messengers from space that are attracted to the Earth and reach the ground before they are burnt up by friction with the atmosphere, are not all of the same composition. Some consist mainly of iron, some of iron and stone mixed, and some almost entirely of stone. In one class of meteorite the iron varies from 80 to 95 per cent. of the whole, and there is generally some nickel. But other metals are also found, such as aluminium, copper, tin, sodium and potassium. Occasionally there are traces of gold, silver and platinum, but it is curious that no meteorite ever examined has contained any element not already found on the Earth. Meteorites are not spherical in shape. They are always irregular, angular fragments, and are often pitted with marks like thumb-marks. These pittings are probably produced during the breaking up of the meteorite when it explodes owing to the heat and expansion caused by the condensation of air in front of it as it rushes towards the Earth. It is the explosion that causes the crash like thunder which is often heard when a meteorite falls. This photograph shows part of a large meteorite which exploded above the U.S.A. and showered white-hot fragments on five separate States. Some famous meteorites are described in page 523.

THE POINT IN SPACE TO WHICH WE ARE MOVING

In the constellation of the Lyre, which we can find by referring to the star charts on pages 415 and 718, there is a star named Vega which means the Falling Bird. It is a star of the first magnitude, and is of very great interest, for it is near the point in the heavens towards which the whole solar system is moving. It is distant from us about 163 million million miles, and its light takes 26 years to reach the Earth.

It is the brightest star in the northern sky, and can be easily seen from all parts of the northern hemisphere as well as from a considerable part of the southern hemisphere.

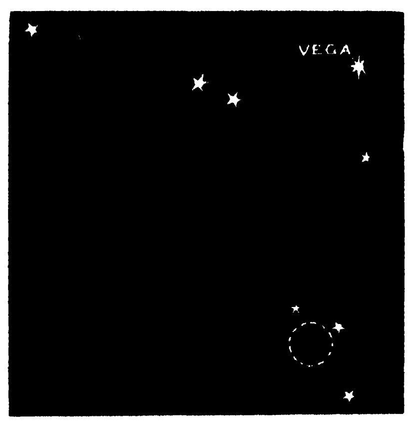
We may find Vega in the following way: two stars of the Plough act as pointers towards the Pole Star, and the next two are pointers towards Vega. Vega is about fifty times as bright as our Sun.

The actual point in the heavens towards which our solar system is travelling is not exactly the star Vega, but a little distance from it, as shown in the star chart given here. The circle indicates the actual point towards which we are moving.

We are travelling towards this point at nearly 44,000 miles an hour, or over a million miles a day. When we remember that we are also travelling at 66,000 miles an hour with our Earth in its orbit round the Sun, and that in the latitude of London we are travelling 700 miles an hour as the Earth turns round on its axis, it would be very difficult indeed to show on a chart exactly the line along which we are travelling at any particular moment. The matter would be still more complicated if we were also walking down the corridor of a train travelling at sixty miles an hour.

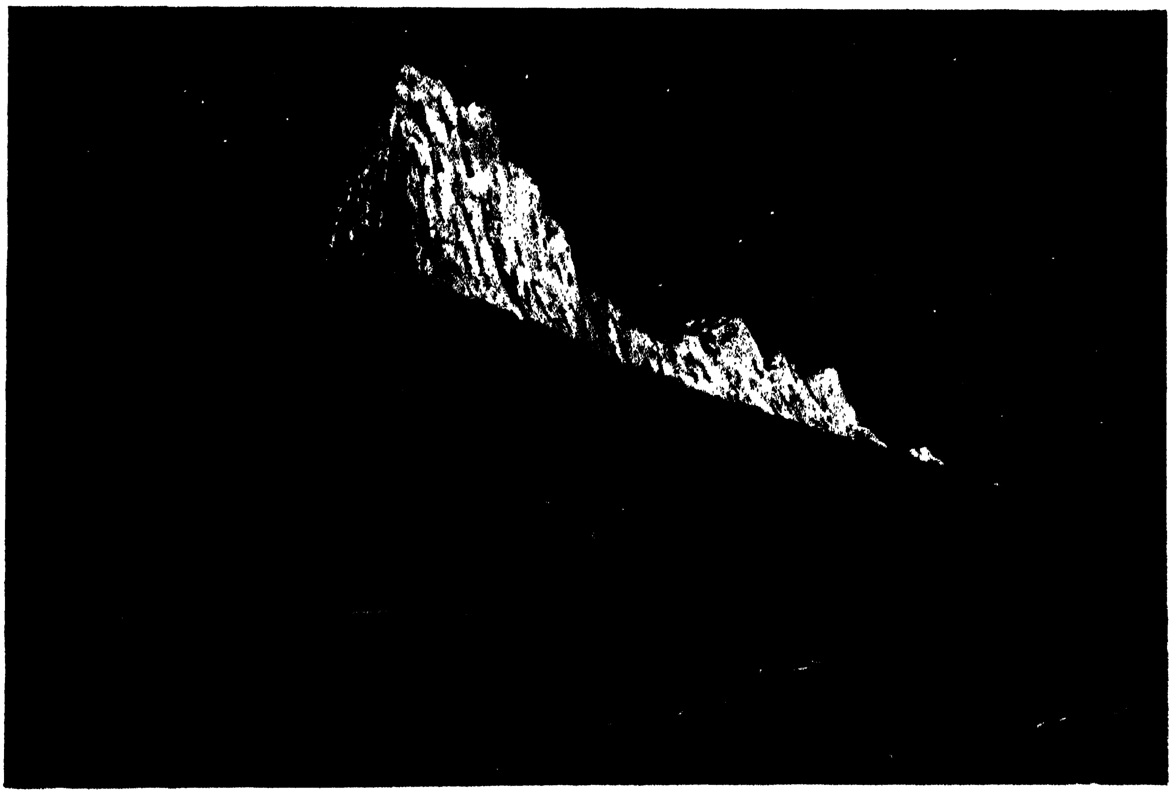
One well-known astronomer, Mr. George F. Morrell, said: "Our actual path in Space is a curve which combines all the directions in question. This may be readily understood by considering a man walking on the deck and around the funnel of a steamer which is travelling in a straight course of, say, 20 miles an hour. Although he appears to be walking round and round in a circle, and is doing so as far as the boat is concerned, yet actually he is walking in a very wavy line that, could the man but see it chalk-marked, as it were, on the sea, would give him the impression that he was a very bad sailor indeed. This is what each of us is doing all the time in Space. We are moving at a terrific rate, whirled from side to side, but ever onward."

In about twelve thousand years' time Vega will be the Pole Star, that is, it will have taken the position of the Star towards which the Earth's north pole points.



The circle near the bright star Vega shows the point towards which the Solar System is travelling at over 1,000,000 miles a day

THE LIFELESS LANDSCAPE OF THE MOON



A day on the moon lasts 354 hours—nearly fifteen earthly days. As the sun creeps slowly across the blue-black sky it picks out the peaks of dead mountain ranges and the rims of deep volcanic craters as with the cold intense white rays of a searchlight. The temperature gradually rises from well below freezing point to about 180° Centigrade on the moon's equator at noon. Dense black shadows are cast in which are dimly seen rounded hills and vast chasms. An artist here depicts the grand but lifeless scene as it would appear to a visitor to the moon's surface. Other representations of lunar scenery are shown in page 1006

THE FOUNDING OF A MIGHTY EMPIRE

The former British Empire in India, the most remarkable and powerful empire that had ever been founded by a European nation outside the confines of Europe itself, owed its inception to one man, and one man only. All Englishmen should honour that man, Robert Clive, the romantic story of whose wonderful and almost unprecedented empire-building in the Orient is told here

We think of the story of Napoleon Bonaparte as romantic and marvellous, but the story of the Englishman, Robert Clive, is quite as romantic and marvellous, even if it is not more so. The two men while little more than boys had vast dreams of a great Oriental empire, and the only reason that Napoleon Bonaparte looms larger in history and in the popular imagination is that the peculiar time and circumstances in which he was placed, and the support he received, enabled him to go farther than Robert Clive

Clive's dreams were as great as those of Napoleon His military genius was equally great, and in some ways his achievements were more remarkable, for while Napoleon had able and loyal lieutenants around him, and an enthusiastic nation at his back, Clive was surrounded by enemies at home and abroad, he was constantly held back by the jealousy of others, and was baulked in almost every enterprise he undertook

Unpromising Circumstances

What makes his case the more remarkable is that, unlike Napoleon, he had no military training. He was just a young clerk compelled to sit for many weary hours each day with a pen, working out dull and uninteresting figures, and with no knowledge of the sword or military strategy or tactics. His superiors were business men without a thought in their heads beyond buying and selling and making as much money out of trade as possible With an empire looming on the horizon all round, and with crowns and thrones hovering within reach, they, like Bunyan's Man with a Muckrake, "did neither look up nor regard," but "could look no way but downwards," though "there stood also one over his head with a celestial crown in his hand, and proffered to give him that crown for his muckrake."

But though the men who directed the policy of the East India Company at home and the men who were in authority in India thought of nothing but trading, the young clerk, sitting in his office, realised the possibilities of a great Indian Empire, and when given only half a chance began to turn his dream into a reality

We owed India to Robert Clive, the greatest empire-builder that England has ever produced, and it is an astonishing thing that his countrymen have so little realised his magnificent achievement, and have so rarely gloried in the astounding exploits which he performed.

One hears much of the romantic wonder of Cortes, who conquered Mexico with a handful of Spanish soldiers, and of Pizarro, who similarly overcame the Incas of Peru and won fabulous quantities of gold as a result But these achievements, wonderful though they were, were small compared with the marvels wrought by Clive in India

As Lord Macaulay has pointed out, the victories of Cortes were gained over savages who had no letters, who were ignorant of the use of metals, who had not broken in a single animal to labour, who wielded no better weapons than those which could be made out of sticks, flints and fishbones, who regarded a horse soldier as a monster, half man and half beast, who took a harquebussier for a sorcerer, able to scatter the thunder and lightning of the skies

His friends and the townspeople stood breathless with terror

Formidable Foes

But the people of India whom Clive subdued were ten times as numerous as the Americans whom the Spaniards vanquished, and were at the same time quite as highly civilised as the victorious Spaniards They had, says Lord Macaulay, "reared cities larger and fairer than Saragossa or Toledo, and buildings more beautiful and costly than the Cathedral of Seville They could show bankers richer than the richest firm of Barcelona or Cadiz, and viceroys whose splendour far surpassed that of Ferdinand the Catholic, myriads of cavalry and long trains of artillery which would have astonished the Great Captain "

Clive, indeed, did what no other man, save Napoleon, would have dreamed to be possible.

As a boy young Robert was regarded as anything but a model by his friends and relatives Even at seven he had a strong will and fiery passions, and was so unruly as sometimes to make his people wonder whether he was really quite sane.

One day he climbed to the top of the lofty church steeple at Market Drayton, where he lived, and seated himself on a stone spout in the form of a dragon's head, which projected near the summit, while his friends and the townspeople down below stood

breathless with terror, expecting every moment that he would crash to the ground and be killed After a time he climbed down safely.

It might almost be said that in his youth he was the first of the gangsters, for he formed the idle lads of the town into a kind of army and levied tribute of apples and halfpence on the shopkeepers, guaranteeing in return that their shop windows should not be broken Modern Chicago might well have got its inspiration from eighteenth century Market Drayton

There seemed no hope that Robert Clive could ever earn a decent living at home, so he was shipped off to Madras as a clerk in the service of the East India Company He might make a fortune, his friends said, but, on the other hand, he was much more likely to die of fever, and then he would cause his family no more trouble

A Tedious Journey

The voyage from England to India was a long and tedious one in those days, but Clive's journey was longer and more tedious than usual. He went via Brazil, and his ship remained some months in South America, with the result that Robert spent all his pocket money before the journey was half over. One good resulted, however, for he picked up a little Portuguese, which helped him later on in India. He was certainly not good at languages, and was never able to converse in any Oriental tongue with the natives of India, but he could make himself understood in Portuguese, a language that some Indians knew, because the Portuguese had long been trading in their country.

In due course Clive arrived at Madras, but he had no friends and no money. His only solace was reading, and the Governor, who possessed a good library, gave Clive permission to use it.

Life was anything but a joy to him at this time.

"I have not enjoyed," he wrote, "one happy day since I left my native country." Twice he tried to shoot himself, but on both occasions the pistol snapped, but failed to explode the powder. "Surely," thought Clive, when he found the pistol was properly loaded, "I am reserved for something great."

About this time war broke out in Europe between England and France and spread to the East, where the French were the more powerful. They captured Fort St. George, Madras, and some of the more prominent Englishmen were taken off under guard to Pondicherry, and led through the town before 50,000 natives.

Clive was indignant, and escaped from the town disguised as a Mohammedan. He took refuge at Fort St. David, one of the smaller English settlements subordinate to Madras, and there begged for and obtained an ensign's commission in the service of the East India Company He was only twenty-one when he began his brilliant military career.

Lord Clive. From the painting by Dance

A few months later peace was concluded between Great Britain and France, Fort St. George was returned to the English company, and the young ensign had to go back to his dreary work at the desk.

But though the two powers were at peace in Europe, there was great rivalry in the East. The once mighty Empire of the Great Mogul was breaking up. The native viceroys were practically independent sovereigns. There were many warring interests among the natives, and only two men saw that it would be possible to found a great European empire on the ruins of the Mogul monarchy. One of these was Dupleix, the French commander at Pondicherry, and the other was Robert Clive, the clerk at Fort St. George.

That the ambition of Dupleix was reasonable many might have agreed, for he had a considerable number of well-trained French soldiers under his command, and the whole of the Indian peninsula was seething with unrest and discontent. But that the young English clerk should have similar dreams would have appeared ludicrous to all.

Dupleix made a brilliant start. He rescued Chunda Sahib, Nawab of the Carnatic, who had been captured by the Marathas, and restored him to his throne. Then he helped to make Mirzapha Jung Subahdar or Viceroy of the Deccan. Naturally, these Orientals were grateful, and showered such wealth and honours and power on Dupleix that in less than twelve months he had become the real ruler of the whole of Southern India, with 30 millions of subjects under his control. He was so carried away with his success that, like a Roman Emperor, he erected a pillar to commemorate his victories, and around it grew up a city, which the French commander arrogantly called Dupleix Fatihabad or the City of the Victorious Dupleix.

Soon afterwards Mirzapha Jung died, and while the French supported another prince of the same family, the English recognised Mahomed Ali as Nawab of the Carnatic.

Gloomy English Prospects

It is not surprising, however, that the natives, who had seen a French flag flying over Fort St George, and the English officials led in triumph through the streets of Pondicherry, should have looked with contempt on Mahomed Ali's supporters. As a matter of fact, his whole realm consisted of Trichinopoly, and even that was besieged by Chunda Sahib and his French helpers.

The English cause was, indeed, in a poor way, but it was at this juncture that Clive, now twenty-five years old, rose magnificently and turned the tide of fortune.

He had obtained a position as commissary to the few English troops of the East India Company, with the rank of captain, and he urged upon his superiors that if the English were not to be driven right out of India they must strike a blow and strike at once.

With the forces at their disposal it was impossible to raise the siege of Trichinopoly, but Clive suggested that a sudden attack should be made on Arcot, the capital of the Carnatic, which would probably have the effect of drawing off the Nawab's force from Trichinopoly.

So scared were the heads of the English settlement at Madras that they agreed to Clive's scheme, and he himself

was put at the head of 200 English soldiers and 300 trained sepoys for the attack on Arcot. There were eight officers under Clive, and of these only two had ever been in action. Four were clerks who, inspired by Clive's example, had offered their services.

The weather was not propitious, but despite thunder, lightning and rain Clive and his little army pushed on to the very gates of Arcot. The garrison of that city were so astounded that Clive and his men should have dared to march through the storm that they were seized with panic and evacuated the fort, which the English entered without striking a blow

Clive began to throw up earthworks and collect provisions, realising that sooner or later the garrison would recover and return to drive him out

This actually happened, and a force of 3,000 men camped close to the town At the dead of night Clive left the fort and surprised the camp. Large numbers of the enemy were slain, and the rest fled, while Clive and his army returned to the fort without the loss of a single man

As soon as news of what had happened at Arcot reached Chunda Sahib and his French friends at Trichinopoly, a force of 4,000 men was sent off to recover Arcot They were strengthened on the way by several thousand native soldiers, and a force of 150 Frenchmen from Pondicherry Altogether 10,000 men arrived at Arcot under the command of Rajah Sahib, the son of Chunda Sahib.

This force at once closed round the fort and things seemed hopeless for the English The walls were half in ruins, and there was no proper protection for guns or soldiers Clive's little garrison was reduced in numbers by casualties, and its effective force consisted of only 120 Europeans and 200 sepoys There were but four officers left and provisions were almost exhausted.

Yet, inspired by the young clerk of twenty-five, this small force held at bay the great army of besiegers for fifty days When the garrison became hungry the sepoys, who had the most profound respect for Clive, came to him and proposed that all the rice should be given to the Europeans, who required more nourishment than the natives The water in which the rice was boiled, they said, would do for them It was an amazing example of devotion which has few parallels in history

An attempt to relieve the garrison from Madras failed, and 6,000 Marathas in the pay of Mahomed Ali, who might have been expected to help, lay idle, as they thought nothing could break the French power, and the English must lose. They were determined not to be on the losing side But the gallant defence of Arcot made them change their minds as to who was likely to be the victor, and their commander decided to march to Arcot to help the beleaguered garrison

No Quarter to be Given

Rajah Sahib therefore decided that the fort must be taken by storm at once But before the assault he offered large bribes to Clive, who indignantly refused them Rajah Sahib thereupon declared that every man in the fort should be put to the sword Clive mocked him, and the Rajah, giving his Moslem followers stimulating drugs to increase their religious zeal, rushed to the attack on a great Mohammedan festival.

Clive was snatching a few hours' sleep when the attack began. He hurried to his post and found that the enemy was driving towards the gates a number of elephants, each with its head covered with iron plates. They were to form a line of living battering rams to force an entrance for the troops. The English fired their muskets, and the elephants, becoming terrified, turned round and rushed furiously back, trampling down the besieging army as they did so. Then a raft loaded with warriors was launched to cross a ditch, and Clive himself took charge of a gun and cleared the raft

Everywhere the young clerk inspired his men The front ranks fired while the rear ranks loaded the muskets, and every shot told For an hour the assault continued, and though several hundreds of the assailants had fallen, the garrison had lost only half a dozen men Then night came, and it was an anxious time At any moment the attack might be renewed, but at last when day broke it was seen that the enemy had scuttled away, leaving behind a number of guns and a large quantity of ammunition

Naturally at Fort St George, when the news arrived, the English were wild with delight They sent Clive reinforcements of 200 English soldiers and 700 sepoys, and with these he captured a neighbouring fort, and then linked up with the Maratha army, now ready to help him

He at once attacked Rajah Sahib, who was still at the head of 5,000 men, including 300 French, and gained another great victory The enemy's military chest fell into Clive's hands, 600 sepoys who had been helping the French deserted and joined Clive, who took them into his service, and other natives and their governors forsook Chunda Sahib's cause and recognised Mahomed Ali as Nawab.

Rajah Sahib gathered another army and attacked the suburbs of Fort St George but Clive again defeated him, killed or captured 100 French, and then, marching to Fort St David, stopped on the way to destroy the Pillar and City of Victory of Dupleix.

The spell of French power was broken. The English authorities at Madras, growing bold under their clerk's inspiration, now decided to send a strong force under Clive to help the garrison of Trichinopoly, but just when the troops were about to start Major Lawrence, who had been on leave in England, returned and assumed the chief command Many a smaller man would have resented being superseded in this way, but Clive, who had experienced many kindnesses from Lawrence in early days, expressed his willingness to serve under his old friend, and worked as hard as second-in-command as if he had been commander

When Clive appeared the garrison of Arcot was seized with panic and evacuated the fort

Lawrence admired his young lieutenant and wrote: "Some people are pleased to term Captain Clive fortunate and lucky, but in my opinion, from the knowledge I have of the gentleman, he deserved and might expect from his conduct everything as it fell out; a man of undaunted resolution, of a cool temper and of a presence of mind which never left him in the greatest danger. Born a soldier; for without a military education of any sort, or much conversing with any of the profession, from his judgment and good sense, he led on an army like an experienced officer and a brave soldier, with a prudence that certainly warranted success."

Dupleix, the French Governor of Pondicherry, was not a soldier, and he had no officer with him worthy to oppose Clive. The besiegers of Trichinopoly had to capitulate, Chunda Sahib was captured by the Marathas, and put to death, and steadily the power of England rose while that of France declined.

Clive's health had never been very good, and it had now become so bad that he decided he must take a rest in England. But before he went he captured two forts held by French garrisons, with a force made up of 500 newly-levied untrained sepoys and 200 recruits who had only just arrived from England. It was a motley army with which to attempt anything, an absolutely undisciplined rabble, but Clive marched with them.

Many stories are told which show their character. When a shot from a fort killed one of the soldiers the rest turned round and ran away, and only with difficulty could Clive rally them. On another occasion the noise of a gun being fired so terrified the sentinels, that they ran away and one of them went and hid at the bottom of a well. Yet the wonderful young English clerk, with the instinct of a true general, gradually trained this force, and with it captured the forts, and defeated a force sent to their relief.

On returning to Madras Clive married, and then with his bride sailed for England. On his arrival he was received with open arms by the heads of the East India Company, whom he had enriched so miraculously, and they presented him with a sword of honour set with diamonds. But Clive refused to receive this token unless a similar compliment were paid to his friend Major Lawrence. It was a graceful gesture, especially in those days of smash and grab.

More astonished at his exploits than the officials of the East India Company were his friends and family. His father could hardly believe that "Bob the booby" could have been the hero of Arcot, but he now acknowledged that he must have been mistaken in his estimate, and he became very proud of his son.

Clive brought home with him considerable sums of prize money, and he was most generous in helping his friends and family, spending thousands in this way.

About a year later Clive sailed once more for India, having been appointed by the directors of the East India Company governor of Fort St. David. The King gave him a commission as lieutenant-colonel in the British Army.

Once more he became a great victor. The Black Hole tragedy had occurred and Clive was sent to avenge it. He planned to replace Suraja Dowlah by a lieutenant of that tryant, a man named Meer Jaffir, and in the negotiations proved himself to be not only a brilliant soldier, but an equally clever diplomat.

Clive himself took charge of a gun and cleared the raft

Plassey, the Decisive Victory

Suraja Dowlah gathered a great army of 60,000 men to attack Clive, who had only 1,000 British troops and twice that number of natives, and a fierce battle took place at Plassey, and resulted in an almost instant victory for the English. Suraja Dowlah's army was routed, its camp, guns, baggage, wagons and cattle were captured, and all Clive lost was 22 soldiers killed and 50 wounded. It is one of the most astounding victories in history, for the great Indian army was well equipped. Suraja Dowlah himself fled, and was later on killed, while Meer Jaffir, who had held aloof in the fear that Clive might be defeated, was placed on the throne. The battle of Plassey gave India to the English.

All Clive's negotiations with subtle Oriental despots may not have been free from criticism, according to our modern standards, but there is no doubt that he was a great patriot, and though, like all Indian administrators of those days, he became rich, he did not acquire a tithe of the wealth which he might have done.

When, some years later, he was attacked in England on account of the wealth he had brought from India, he made the classic remark: "By God, Mr. Chairman, at this moment I stand astonished at my own moderation!"

The battle of Plassey sounded the knell of French hopes in India, and from the time of that victory the English star rose in the Indian sky. It was Clive and Clive alone who placed England as the supreme power in India.

Yet his ungrateful employers, jealous of his fame, although benefiting by the wealth he brought into their coffers, made his life unhappy. Some of the directors of the East India Company became his enemies and although, when affairs became once more desperate in the East after his return to England, Clive was sent out to set them right, these men still worked against him and tried to deprive him of part of his wealth, till at last it is said he committed suicide, although as to the manner of his death there seems to be some doubt.

Let all Englishmen remember with gratitude and pride Robert Clive. It was his dazzling dream of a British Empire in India which first gave the vision of what Englishmen might make of the Great Mogul's realm; it was his brilliant military genius and leadership that made the Empire possible; and it was his able administration which abolished the old system of oppression, extortion and corruption and placed British rule on the high plane which it has ever since occupied.

"Our island," says Lord Macaulay, "so fertile in heroes and statesmen, has scarcely ever produced a man more truly great in arms or in council."

HOW PICTURES ARE REFLECTED

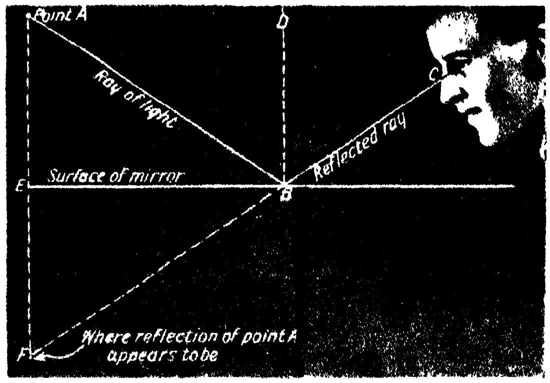
How little we think when we look into the mirror and see a representation of ourselves what a wonder this is. Here we read something about the mystery of reflection, and see a number of striking examples

WHEN the weather is calm and the light good we can see clear pictures in a lake or puddle, and some striking examples of such reflections are found in the photographs in these pages.

Why is it that we can see a picture in the water? Light when it strikes a polished surface is reflected, or bounced back as it were, in the same way as when we throw a rubber ball at a wall it returns. If the ball strikes the wall perpendicularly it returns along the same line, but if it strikes the wall slantingly it goes off at the same angle in the opposite direction.

Light behaves in the same way. As men of science say, "the angle of reflection is equal to the angle of incidence," which simply means that when the light strikes a mirror or other polished surface at a certain angle it is reflected at a similar angle.

We can understand the matter by looking at the diagram on this page. That diagram shows how light coming from a point strikes the surface and is reflected. The same thing is true of light striking the surface from an infinite number of other points. Thus, if we see a tree reflected in a pond the light is passing to the surface of the pond from myriads of points of the tree, the total making up a representation of the tree which is reflected to our eye.



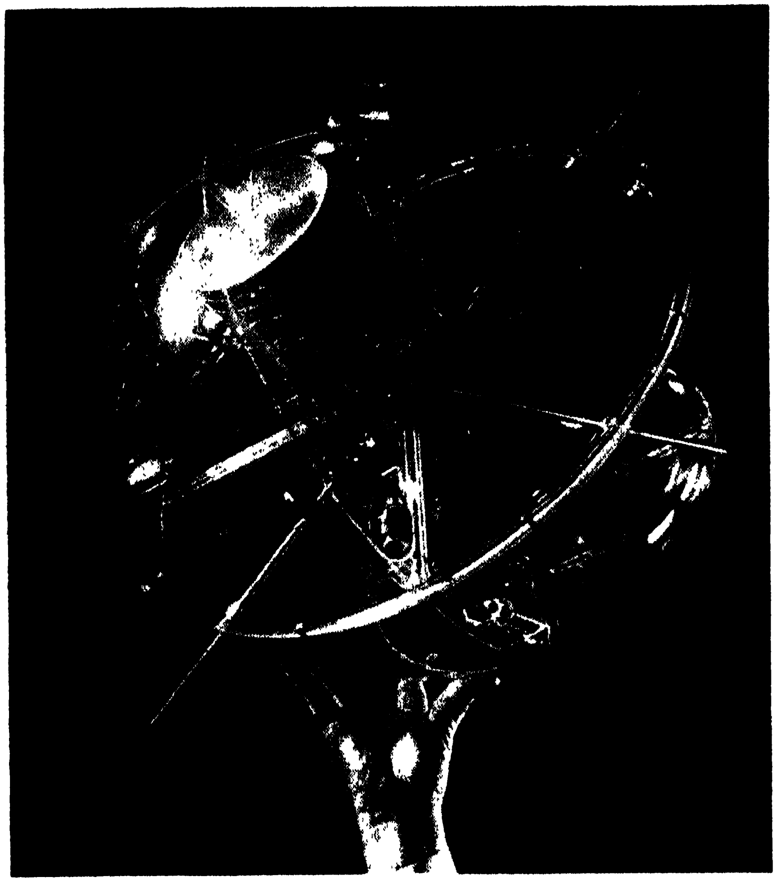
This picture explains why we see in a mirror a representation of what is before it. Light reaches the mirror at B from the point A and is reflected at a similar angle in the opposite direction. That is, the angle A B D is equal to the angle D B C. But the eye is deceived and sees a reflected ray as though it were coming from the point F. It will be found that when a perpendicular line is dropped from A cutting the surface of the mirror the reflected ray, if continued, always cuts the perpendicular at the same distance below or behind the mirror as the point of light is above the mirror. In other words A E is always equal to E F. That is why the image of an object always appears behind a mirror at a distance equal to that of the actual object in front of it

The image of any point appears behind the mirror at a distance equal to its actual distance in front of the mirror. The reason for this is also explained in the diagram.

In some restaurants and halls large mirrors are placed on the walls facing one another. Theoretically, the number of reflections between the two mirrors is infinite, and as we look into one of them we seem to see an endless suite of rooms. Actually, however, the number of visible reflections is only about twenty. The reason for this is that not all the light is reflected. A certain amount is absorbed, and so by about the twentieth reflection there is not sufficient light to come back to our eye and the multiplication of pictures is no longer carried on.

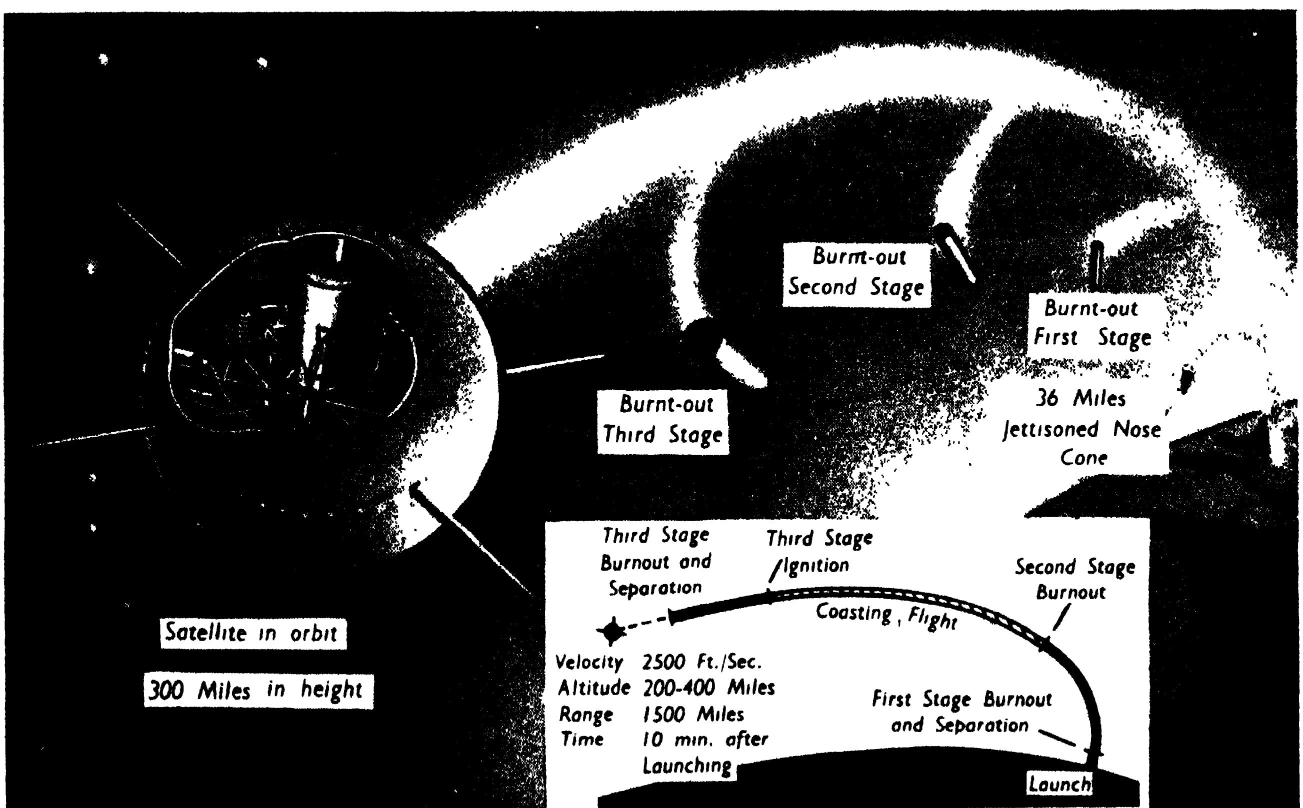
A striking reflection of three riders seen on the beach at Blackpool The tide had only just gone out

MAN ADDS TO THE SOLAR SYSTEM

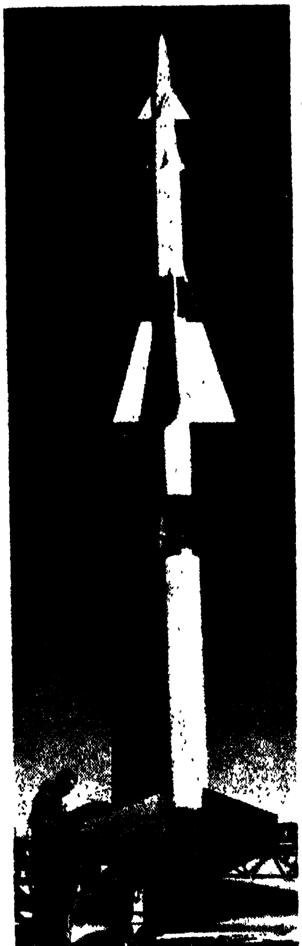


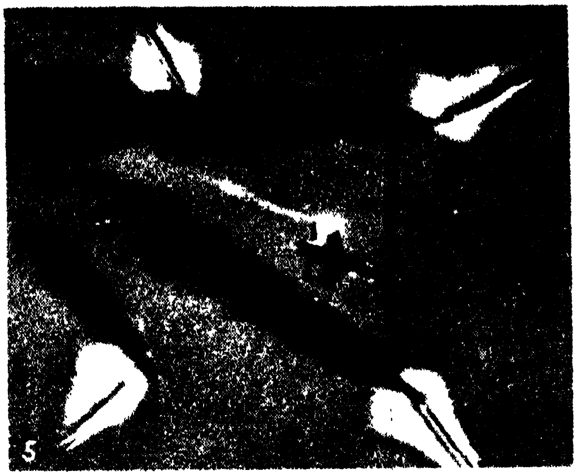
With the object of gathering information about conditions obtaining in outer space, the U.S. and Soviet governments carried out in 1957–58 a programme of research with artificial satellites designed to encircle the earth at altitudes of 200-400 miles. The Russians successfully launched the first satellite on October 4, 1957. It consisted of a metal ball containing a radio transmitter which emitted signals whereby its course round the earth could be plotted. Later satellites consisted of a hollow sphere of stainless steel coated with gold and 30 inches in diameter—only slightly larger than a football. The inside of the sphere was packed with a mass of instruments for recording temperature and pressure changes, cosmic and other radiation, electronic equipment for converting such information into electric impulses, and a radio transmitter for relaying the instrument readings to receiving stations on the earth. The photograph on the left shows one of the U.S. spheres with a transparent cover to show the recording equipment.

The satellites were fired into space by means of a three-stage rocket, each stage falling when its fuel was consumed as shown below. The last stage of the rocket then fired the satellite at a speed of 18,000 miles an hour into an orbit round the earth. Travelling at a speed of 18,000 miles an hour, the satellite created sufficient centrifugal force to balance the gravitational attraction of the earth. In time, however, the centrifugal force becomes weaker and gravity pulls the sphere back to earth ; but before the sphere reaches the ground it is destroyed by the friction of the atmosphere. Throughout its course round the earth the satellite can be observed by telescopes ; which is rather like watching the course of a golf ball in flight if it were travelling at the speed of sound 60,000 feet away.



ANTI-AIRCRAFT ROCKETS THAT CAN THINK





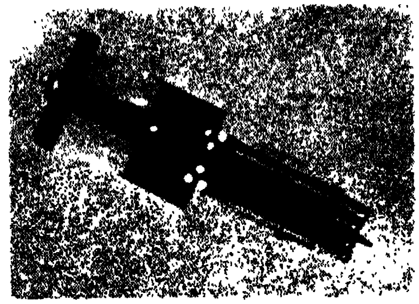
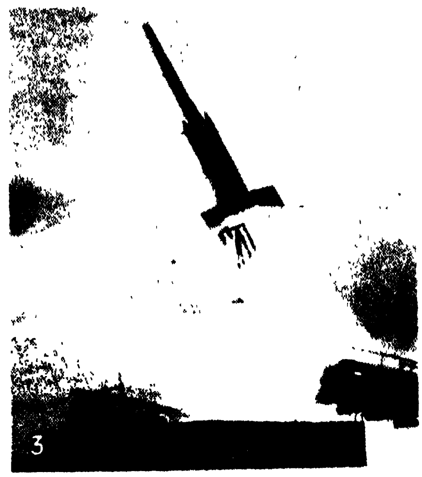
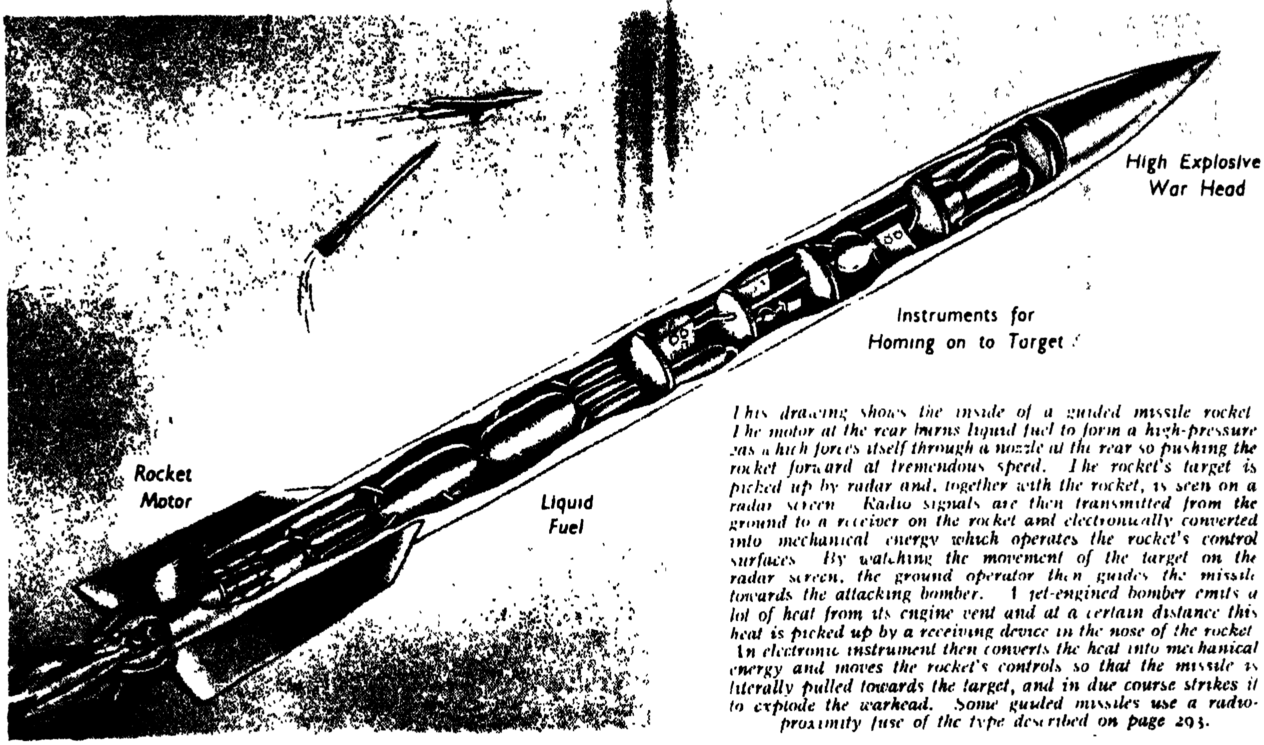


Fig. 3. A British guided missile at the moment of firing. It uses four solid-fuel rockets for take-off, but at a certain altitude these burn out and fall away, after which the missile is propelled towards its target by means of a ram-jet motor. 4. The missile shortly after take-off and showing the auxiliary rockets mounted at the rear. 5. The auxiliary rockets dropping off.



With the development of the high-altitude, jet-propelled bomber flying at or above the speed of sound, the anti-aircraft gun became obsolete, as the target moved too fast for the gunners to keep it in sight and too high for the shell to reach it. It was to overcome these difficulties that the guided missile was introduced. A guided missile consists of a rocket containing radio and radar equipment whereby it can be guided towards its target, and a device that automatically explodes its warhead when it comes within range of the bomber. Fig. 1. Nike, a two-stage missile rocket used by the U.S. Air Force. It is 26 feet long, weighs 9 cwt., has a speed of 1,330 m.p.h. and a range of 17 miles. Fig. 2. Nike after firing; first stage rocket about to fall away



This drawing shows the inside of a guided missile rocket. The motor at the rear burns liquid fuel to form a high-pressure gas which forces itself through a nozzle at the rear so pushing the rocket forward at tremendous speed. The rocket's target is picked up by radar and, together with the rocket, is seen on a radar screen. Radio signals are then transmitted from the ground to a receiver on the rocket and electronically converted into mechanical energy which operates the rocket's control surfaces. By watching the movement of the target on the radar screen, the ground operator then guides the missile towards the attacking bomber. A jet-engined bomber emits a lot of heat from its engine vent and at a certain distance this heat is picked up by a receiving device in the nose of the rocket. An electronic instrument then converts the heat into mechanical energy and moves the rocket's controls so that the missile is literally pulled towards the target, and in due course strikes it to explode the warhead. Some guided missiles use a radio-proximity fuse of the type described on page 293.

EXPERIMENTS WITH POROUS SUBSTANCES

All the substances we know are porous, that is, they have pores or spaces between the molecules or particles of which they are built up. Of course, the pores are not the same size in all substances, but although in a piece of marble the molecules are packed much closer together than in a piece of chalk, yet it

A match and coin experiment

is nevertheless true that the marble is porous in the same way as the chalk is.

We call some substances, such as clay and india-rubber, impervious or non-porous, but this does not mean that they have no pores: it simply means that the pores are so small and the molecules so close together that they will not allow water to pass through them.

A flower-pot made of baked clay is porous enough for water to pass through slowly, but if it is glazed on the outside, that

The home-made fire-lighter made from pumice-stone that has been soaked in paraffin

Taking grease out of cloth by capillarity

is it it is covered with a thin coating of glass, it is impervious to water.

We have already seen that when a porous substance is placed in a liquid such as water, the liquid rises in the pores of the substance, and this is called capillarity or capillary attraction. The word comes from the Latin word *capilla* meaning a hair, and it was given because water rises in a very small tube something like a hair in diameter. Some experiments illustrating capillarity and porosity are given on page 780 and here are some more.

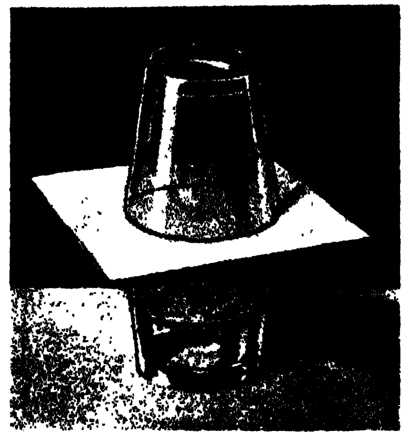
In the first experiment we take a wooden match and bend it at an angle without quite breaking it. We place it on the neck of a bottle as shown, and lay on it a sixpenny-piece. The neck of the bottle should be big enough for the sixpence to pass through it easily. Everything being arranged, we tell our friends that we will make the coin drop into the bottle without touching or shaking it or the match or the bottle.

This is done by letting fall on the angle where the match is bent a drop of water from our finger. The porous wood soaks up the water and in doing so swells and the two halves of the match slowly open, allowing the coin to fall.

If we get grease on our coat, we can get it out by a simple scientific experiment. We place the coat on a table, lay over it a piece of absorbent brown paper—not the shiny sort—and then press it with a hot iron. The heat melts the grease on the coat and the porous paper soaks it up out of the coat by capillary attraction.

Housewives and maidservants often perform a scientific experiment in order to make a fire light easily. They place a piece of pumice-stone, which is the hardened froth of lava and is very porous, in paraffin. It soaks up the oil and its pores become filled with the paraffin. Then it is placed in the grate with the paper and wood and lighted, the paraffin burning. The pumice-stone is used again.

We can easily prove that cardboard is porous by placing over a tumbler of hot water a card, and then inverting another tumbler on top of this. Steam will pass through the pores of the card and condense into water above.



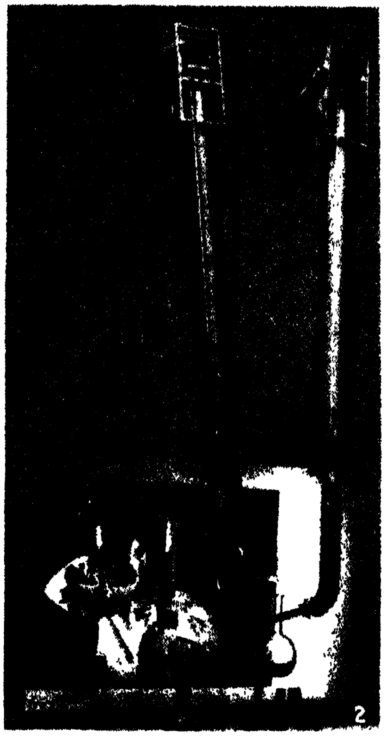
Proving that cardboard is porous

Another experiment illustrating porosity is the preparation of a home-made filter. We take a large flower-pot and stop up the hole with a clean piece of sponge. Then we put in a layer of coarse sand or broken up flower-pot material. Next we place a layer of finer sand and then a layer of silver sand. On top we place a small piece of slate for the water to fall on, so as not to wash away the sand. The water will be filtered in percolating through the layers.

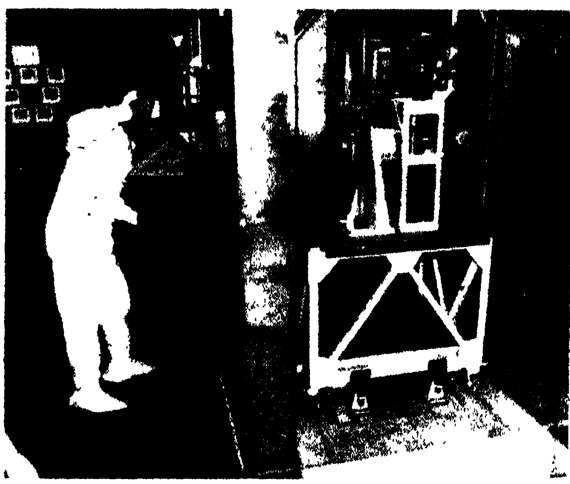
A filter made from a flower-pot and sand

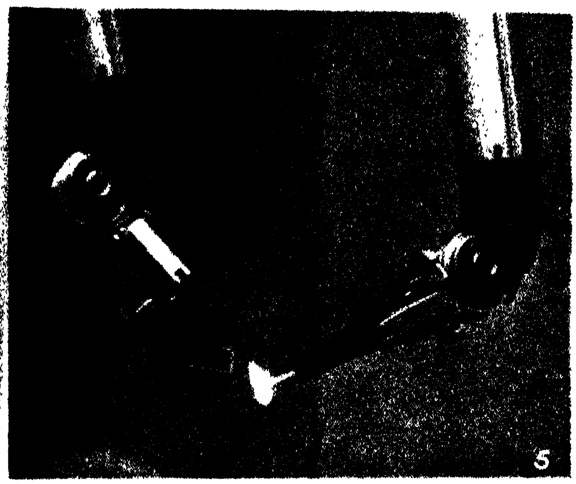
A final experiment is very simple and very interesting. We drop a piece of chalk, such as is used for writing on the blackboard, into a glass of water. At once bubbles of air are seen rising to the surface of the water. What is the explanation? The bubbles consist of air that was in the pores of the chalk and is driven out by the water. The chalk is now heavier owing to the absorbed water.

ROBOT HANDS THAT BEAT DEATH RAYS



Touching radio-active materials can cause serious injury to human beings, and elaborate precautions are taken to protect scientists and technicians who have to handle atomic substances. These photographs show an ingenious pair of robot hands with which an operator can manipulate articles separated from him by a protective wall of concrete and lead several feet thick. Each " hand " consists of over 500 moving parts. 1. On the "safe" side of the wall an operator uses the finger controls to go through the motions of pouring a liquid from one container into another. 2. On the " danger " side of the wall the robot hands obediently obey their master. 3. A technician watches the mechanised hands strike a match under his direction, as shown in 5. 4. An operator moves radio-active material separated from him by a lead wall ten inches thick. 6. How to shave by remote control. 7. The "barber" gets a view of his customer on a T.V. screen





HOW ELECTRICITY IS USED TO WELD METALS

Welding is now done by means of electricity, and here we see a method of electric welding in which the current is applied to the two pieces of metal that are to be joined. The heat produced by the current melts the two faces and unites them as one piece

In this picture we see electric welders at work on a boiler at the London underground railway power station at Neasden, where, in order to speed up, many of the old boilers were taken out and replaced by modern plant, in which the steam pressure is 900 pounds to the square inch. Electric welding saves a great deal of time and labour in the joining up of connections, and so on.

MARVELS of MACHINERY

"SEWING" METALS WITH ELECTRICITY

For centuries, blacksmiths have welded wrought iron by heating the pieces almost to melting-point and hammering them together on an anvil until they become as a single piece. This very ancient method could be used only on comparatively small pieces easily heated in the smith's forge. Nowadays, metal parts weighing many tons can be joined together in a fraction of the time by using an electric spark.

METALS can be electrically welded either by generating an arc of high temperature or by taking advantage of the phenomenon that metals' resistance to an electric current creates enough heat to melt the metal so that two pieces of metal will weld together by fusing.

In arc welding, the heat is provided by striking an electric arc between the work and a metal rod or "electrode" held in an insulated handle by the operator. As it melts, the rod supplies extra metal to the weld, which is deposited in the pool of molten "parent" metal and built up as required.

Electrodes are according to the type of work for which they are required. An electrode which would be quite suitable for ordinary "mild" steel plate would not do for stainless or other alloy steels or for cast iron. Electrodes are coated with various chemicals which fuse into a molten "slag" that floats on top of the weld and helps to keep the metal free of contamination by air or by gases from the arc.

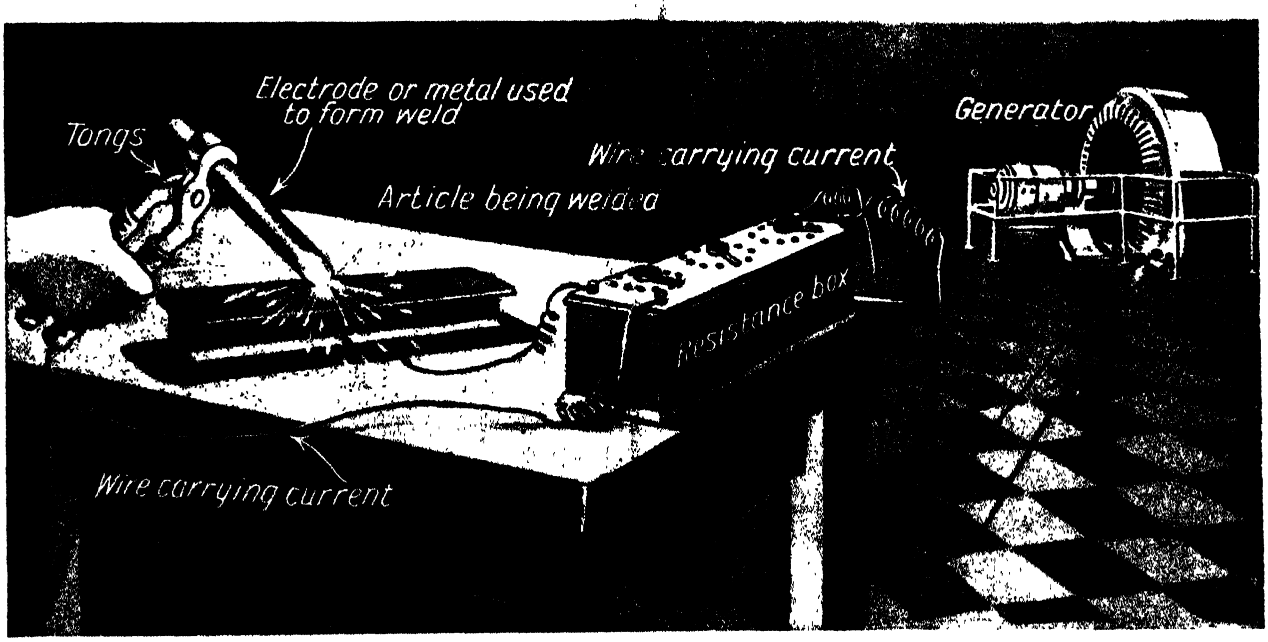
Automatic arc welding uses a long reel of coated electrode which is fed into the arc automatically. The entire apparatus is mounted on a movable carriage which travels along, welding a long seam as it moves. This is often used in shipbuilding.

In carbon arc welding, the arc provides only heat for melting, the additional metal coming from a separate filler rod. In "atomic hydrogen welding," the arc, instead of being struck between an electrode and the work to be jointed, is struck between two tungsten electrodes. One is hollow, and through it is blown a jet of hydrogen. This also is used with a separate filler rod.

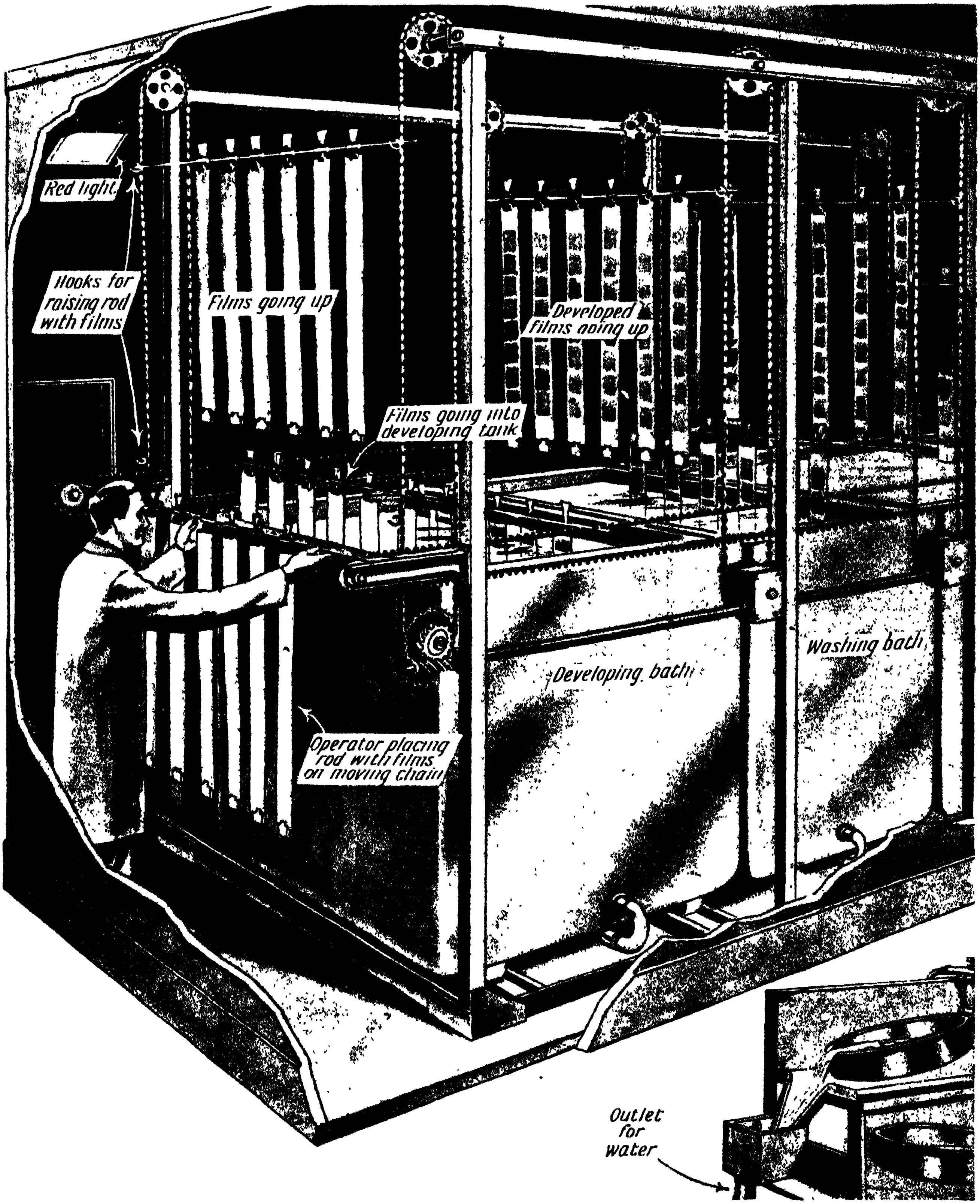
With resistance welding, no additional metal is supplied. Joints are made by heating the metal to its softening point by passing a heavy electric current through it, so that it heats up by its own resistance, and then squeezing the joint together. The best known method of resistance welding is spot welding, largely used for joining thin sheet metal together. The two sheets are laid in position between the two electrodes of a machine and, by a pedal (or by compressed air cylinder in large machines) the electrodes are pressed together. A heavy current passed between them makes a hot spot right through the metal which, under pressure, unites into a solid core running right through both pieces almost like a rivet. A variation on this method is "stitch welding," where by a line of spots very close together two pieces of metal are, as it were, stitched together.

By the use of wheel electrodes in place of pointed ones, "seam" welding can be carried out, the metal being slowly passed between the wheels, and a solid seam formed. The current is not left on continuously, but is automatically switched on and off again at a very rapid rate.

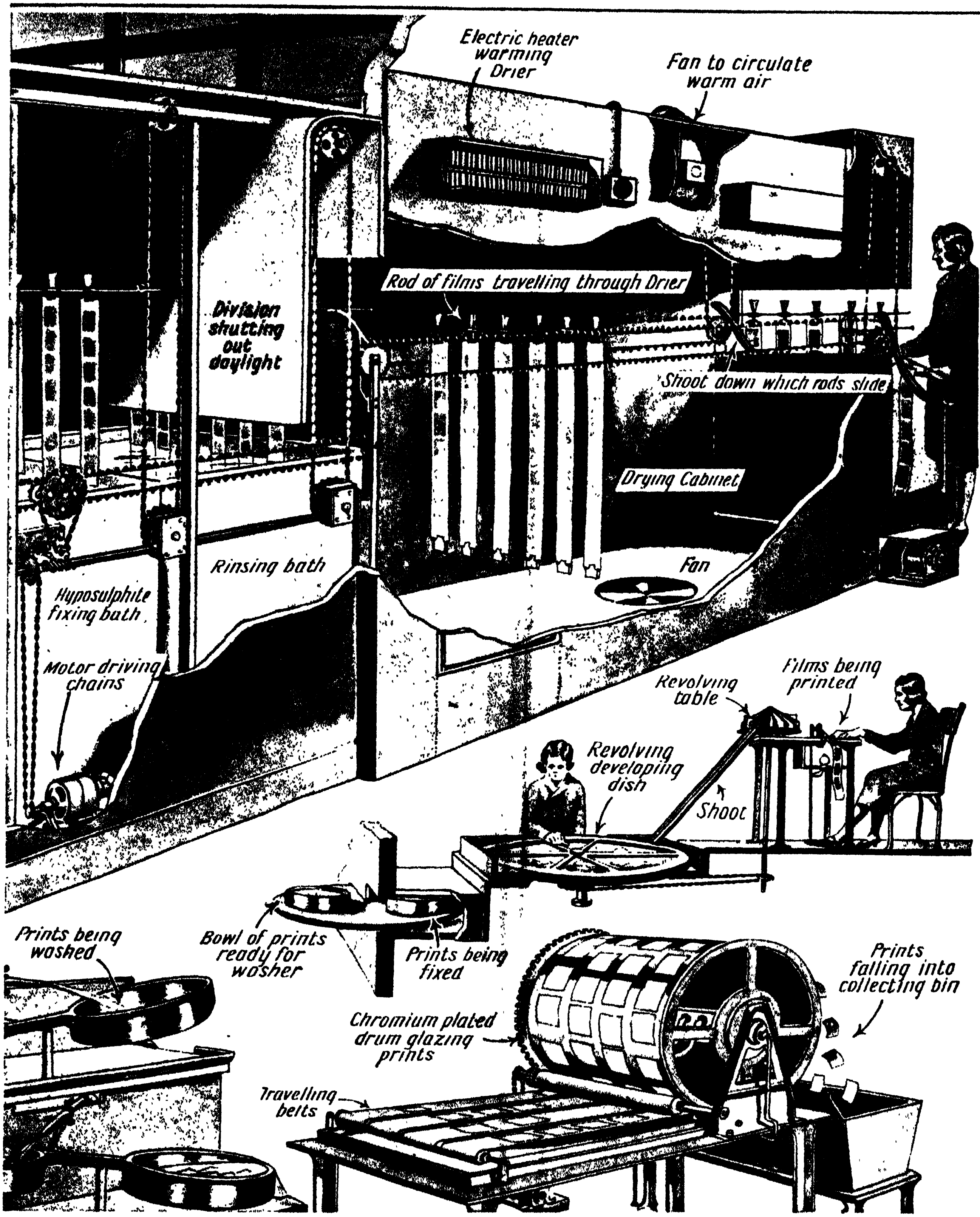
"Flash-butt" welding is used for joining steel pipes and railway track. The two pieces to be joined are held in the jaws of a machine, and pressed tightly together while a heavy current passes through them. Since the maximum resistance is at the joint itself, it rapidly heats up, and the metal is softened sufficiently for a perfect weld to occur.



This picture-diagram explains how electric welding by the arc process is carried out. A wire carries the current from a generator through a resistance box, where it is regulated, and conducts it through one handle of the pincers to the electrode or metal used to form the weld or joint. The other wire from the generator conveys the current to the article that is to be welded. When the operator brings the electrode to the article an electric arc is formed which melts the metals, and the crack or joint is filled up. The various surfaces become one piece of metal. The temperature reached during the process is very high.



Here is a machine that develops thousands of photographic films a day. The films are unrolled and each is fixed in the lower part of a double clip. In the upper part of the clip the customer's order form for that particular film is fixed. The film and its order form thus remain together. The operator slides the clip holding the film on to a rod, and when a number of films are on this rod he places it on a chain, which is moving slowly in a horizontal direction. The rod travels along until it meets a chain moving up vertically. On this chain are hooks which, coming under the rod, lift it and carry it up and over two wheels and then down the other side and into a developing bath. As it comes down the rod is once again transferred to the slow-moving horizontal chain, which carries it along through the developer. On reaching the end of the bath it is once more caught and lifted up and over by a second vertically moving chain. In this way it passes in turn through a washing bath, a fixing bath and a rinser. Then the rod is caught and lifted and comes down into a drying chamber. Here it is transferred once more to a slow-moving vertical chain and carried the length of the drier, which is full of warm air, circulated by fans in the roof and floor. The rod of films, on reaching the far end of the drier, is again taken up by a vertical chain and coming down once more slides down a chute and is lifted away by a girl. All through the machine it has been in the dark, but it is now in the daylight. The girl passes the films through a little opening in the



wall, where they are received for printing. The printer passes each film in turn through the printing frame on the table, where each subject is exposed on a piece of bromide paper, a light being switched on for the purpose. When each piece has been exposed, the bromide paper is placed in a pigeon-hole on a slowly revolving circular table, which carries it round and drops it through a slide. It then falls down a chute into a division of the developing dish, which is also slowly revolving. By the time the dish comes round to a girl sitting before it, the print is developed and she takes it out and places it in a metal bowl, which she revolves. The bowl of prints is now ready for the washing department. There the prints are placed in one of two containers arranged together like a pair of scales. Water from the tap is playing into one scale, and when this has a certain quantity of water in it it goes down and, in doing so, rotates a lever connected with the tap. The lever directs the tap round towards the other bowl, and meanwhile the bowl which was forced down is emptying itself of water, and as soon as its companion bowl is full, that sinks and the empty one rises to its previous position. A girl now takes the washed prints and places them on one of four travelling bands which carry them round a roller. This roller presses out the surplus water and passes them on to the chromium-plated face of a large drum, which is heated by electric radiators inside. By the time the drum has carried the prints up they are quite dry and fall off into a collecting bin.

RAILWAY SIGNALS OLD AND NEW

THE safety of a railway depends upon its signals, and one of the most responsible jobs on the line is that of signalman We all ought to raise our hats to the signalmen who make it possible for us to travel to and fro every day between our homes and our school or work in perfect safety

In the very early days of railways the signalling was done by hand and a flag was waved by day and a lamp by night Of course, in those times there were not many trains, but as soon as the railways began to develop it was felt that something more satisfactory was needed

Soon posts were provided on which the pointsmen could place lamps at night and a disc was added which could be worked from below by a lever, covering the light with a red or white glass, as required. This disc was used as the signal in the daytime. When it was turned to face an approaching train it meant stop, but if the disc was turned edgewise it meant go on. The signalmen in those days wore swallow-tailed coats and top hats.

In 1842, that is seventeen years after the opening of the first railway, the authorities adopted the semaphore system still in use. Semaphores had been used for sending messages across country in the days before the invention of the electric telegraph, and it was from these that the railway people got the idea.

It was arranged that when the arm was in a vertical position it meant "safe," when horizontal "danger," and when aslant "caution" At first there was a man at each signal post or each pair to work the arms, and it is said that the idea of working them from a distance originated with a lazy or overworked Irish porter employed on the London and North Western Railway who, having two signal posts close together to work, tried to think out some idea which would save him the trouble of walking to and fro between the two posts

He placed a counterweight on the handle of one signal and fixed a clothes-line to it so that he could work it from the other post An inspector detected the device, and saw in it great possibilities. He improved on the idea, and soon the signal system, worked from boxes, as we have it to-day, was introduced all over England.

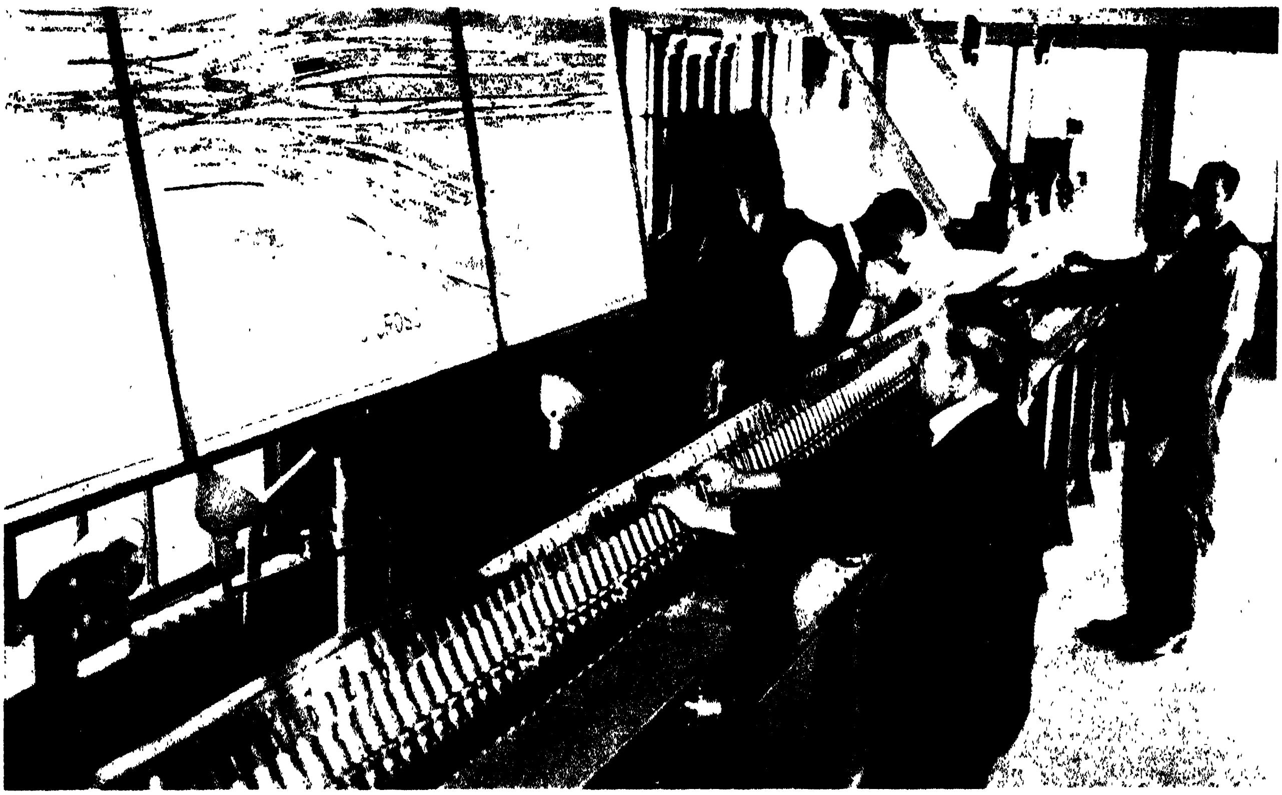
Then came the interlocking idea, by which when at a junction the lever working a main line signal was lowered, it was impossible to work the lever of a branch line, and thus render a collision possible. Soon afterwards a way was found of connecting the points with the signals, so that it was impossible for a train to enter a branch line while the signal was against it.

In our present semaphore signals the horizontal position of the arm means "stop," and when the arm is dropped to an angle it means "go ahead" For night use a frame known as the "spectacles" is used This contains red glass to cover the light meaning "stop" or "danger," and a green glass for "caution" or "go on."

It was a wise precaution in England to use green for safety. In the United States, where white was used for the same purpose, many accidents were due to the engine driver mistaking some other light for a signal light

In Great Britain the semaphore arm appears to approaching trains on the left-hand side of the post, and the same post is used for up and down trains.

In recent years there have been great developments in the system of signalling, especially on electrified lines

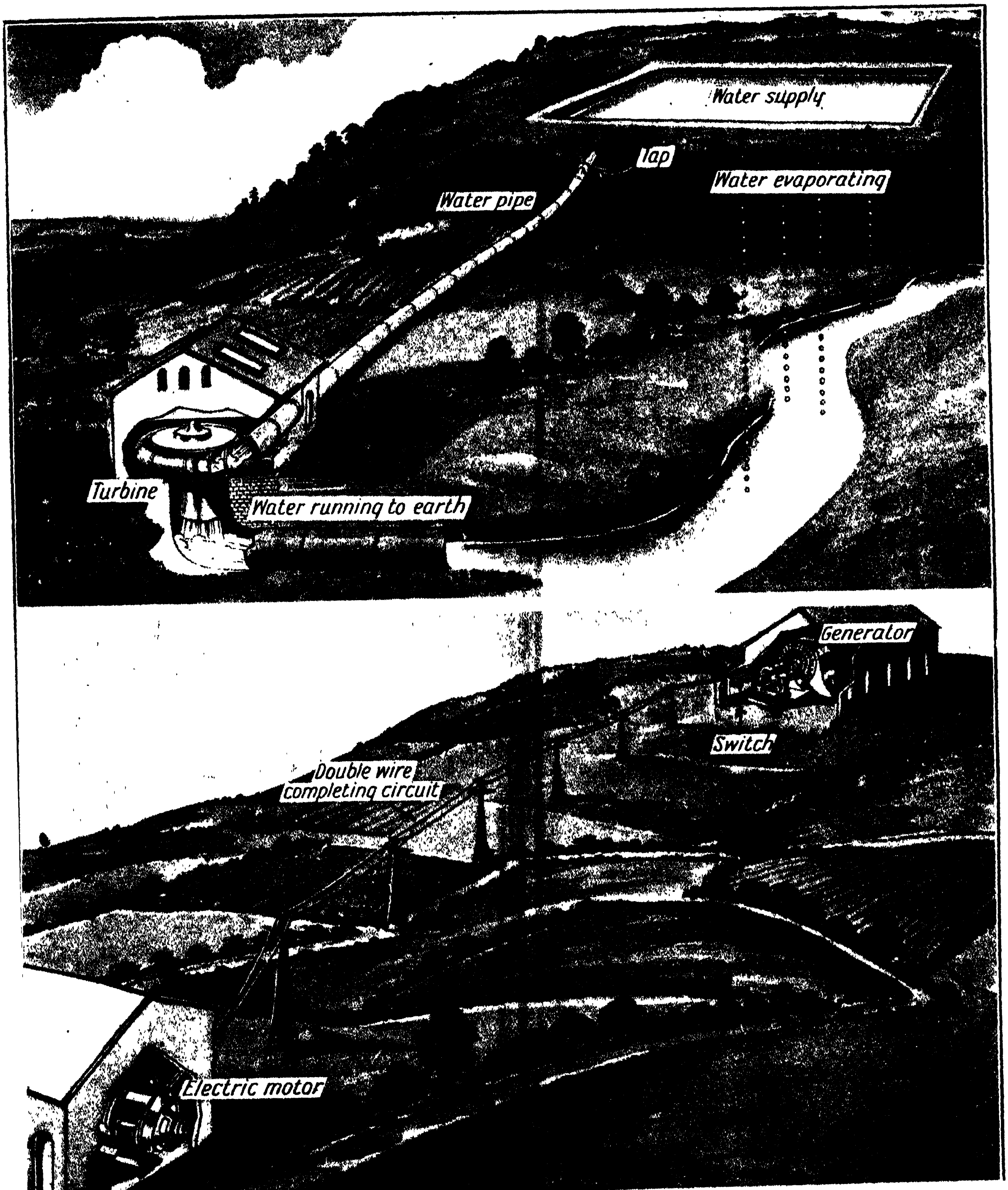


Inside the wonderful new signal-box at King's Cross Station, London, where there are 232 levers and an illuminated chart on which the movements of each engine and train are indicated. In this box 18,000 lever movements are made every day

At King's Cross Station in London, there is a box controlled by an official known as a regulator. This has been necessitated by the development of electric colour light signalling. Every twenty-four hours 800 trains and engines move out of the station, and to enable them to do so with safety more than 18,000 lever movements have to be made in the signal-box.

There are 232 miniature levers, working 142 signal lights, and the regulator, three signalmen and a telegraph lad work with an illuminated chart before them on which the movements of each engine and train are in licated automatically as they occur. It is a wonderful safety-device.

WATER POWER AND ELECTRIC POWER COMPARED



In these pictures we see an interesting comparison between water power and electric power. The top picture shows water power and the bottom one electric power. In the first case the source of power is a tank or other supply of water at a height, and in the second case a battery or generator. The water flows down a pipe, being released by the turning of a tap, and the electric current flows along a wire, being released by the turning of a switch. The pressure of the water in the pipe corresponds with the voltage of the electric current and the quantity of water with the number of watts. The friction of the water against the inside of the pipe corresponds with the ohms or resistance of the current as it passes along the wire, and the rate of flow per second of the water corresponds with the number of amperes. Just as the water conveys the power of the head of water to the water-wheel or turbine and turns it, so the wire conveys the electric current to the motor and turns it. The water finally runs away to earth whence by evaporation it rises to the tank once more, and the electric circuit is completed by a return wire

THE GENTLE RIPPLES BREAKING ON THE BEACH

When we are at the seaside on a calm sunny day and see the gentle waves or ripples breaking softly and almost silently on the smooth, sandy beach, as in this photograph taken at Scarborough we hardly think of the sea as a destructive force. Yet even in this gentle mood it is busily at work wearing away the coast. The mere movement to and fro of the water against rock and cliff wears away the land, and even the small sand grains of a smooth beach like that shown in the picture act as a sand-blast and grind away relentlessly. When, however, the beach is made up of coarser fragments, then the wear and tear is much more marked. The rocky fragments, hurled again and again against the shore, act as so many miniature battering rams and sooner or later make a breach in the rampart. Then when the cliff or rocky shore is once broken the rent is made wider and wider by the incessant battering

THE WAVES THAT BREAK ON THE SHORE

The breaking of the waves on the sea-shore is an interesting phenomenon. The fact that thousands of people every summer sit or stand watching the tide come in shows that the action of the water is interesting. But the interest is greatly enhanced if we look at the waves intelligently, and understand the reason for their action, comparing their behaviour on one day with that on another, and at one place with that at another

ANYONE who has spent a holiday at the seaside soon comes to realise that the way in which the waves break upon the seashore varies a great deal at different times and at different places.

On a smooth, sandy beach with a gentle slope in calm weather the waves can hardly be said to break at all, and there is little of the foam that we associate with the breaking of the waves. On the other hand, if a fierce storm is raging the waves, which are due to the wind, are large and angry, and their crests are lashed into foam as they hurl themselves upon the beach.

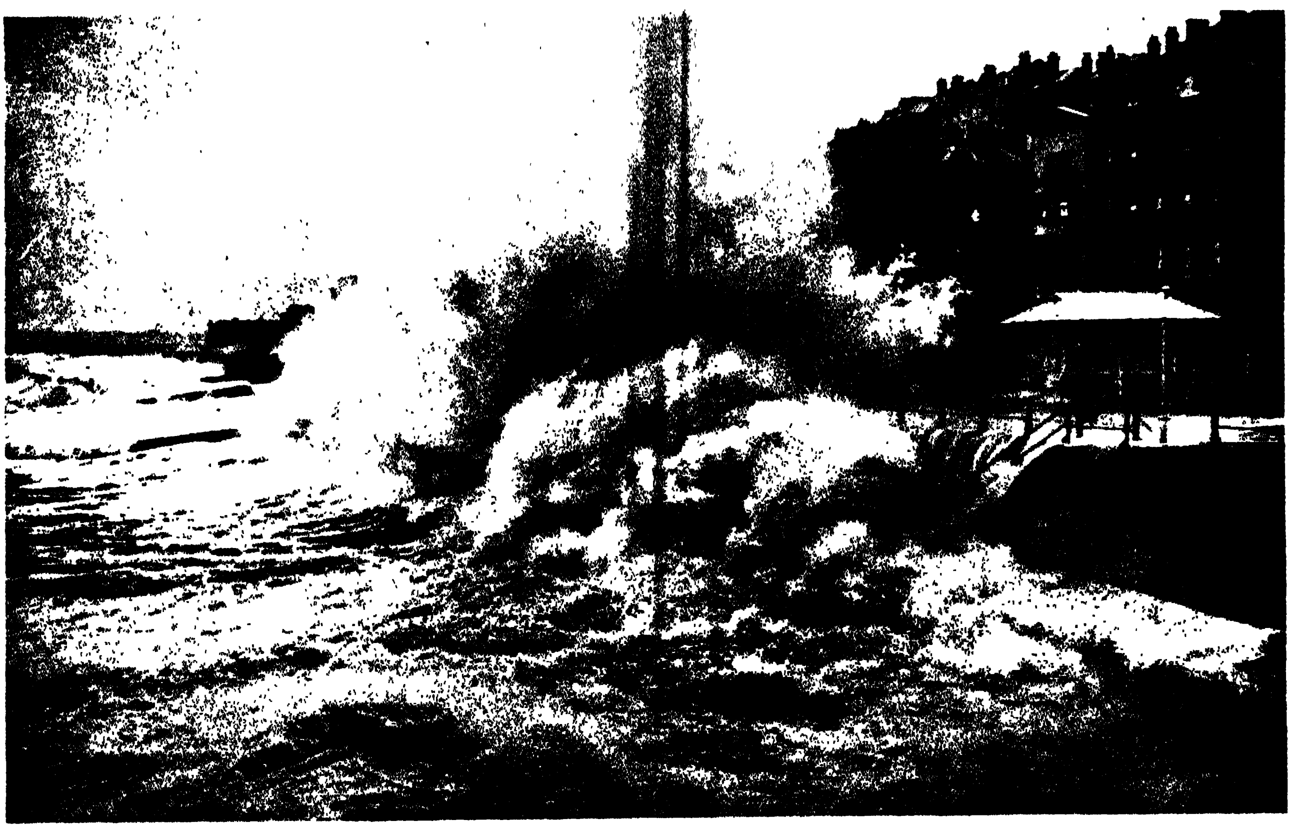
Where the shore is rocky and there is any wind at all, the breaking of the waves is always accompanied with a good deal of roar and disturbance.

It is quite interesting at the seaside to watch the varying behaviour of the waves at different parts of the coast, and in different weather conditions. Along the exposed coast-line of the English Channel, for instance, the effect of the waves varies a great deal. When the wind is blowing offshore, the shingle or other material on the beach is heaped up, but when there is a wind blowing on to the shore it is swept down again.

Exactly why it is that the offshore wind piles up the shingle or pebbles on the beach is not quite clear, but it is believed to be due to the fact that the wind breaks the onrush of the wave crest, and this causes the base of the wave to push the beach materials up. As there is no scouring action by the crest of the wave to draw them back, the materials are able to accumulate.

The shape of the shore has a great deal to do with the form and action of the waves that break upon it, and if the shore is neglected its shape soon changes. The gradient grows steeper, or the coast-line is eroded. When a wave approaches the beach, it drives a mass of shingle up the slope, and then when the force of the wave is exhausted the water recoils or flows back at right angles to the coast-line. Although much of the material pushed up by the wave is dragged back again in the recoil, a certain quantity is thrown up permanently and does not fall back.

In planning a seaside town it is always better to leave a wide belt of lawns and gardens between the sea beach and the foremost houses than to build a high sea-wall and have the houses very near the high water line. Sea-walls, although necessary to protect existing towns, generally produce a dangerous scour of the waves, and, to avoid this, groynes have to be built out, at great expense, to counteract the action of the waves. Sand or shingle collects round the groynes and helps to strengthen them



The waves in an angry mood breaking fiercely against the sea-wall at Hastings. It is the wind that lashes the sea into this angry form

WEATHER CLERKS NOW HAVE HIGH AIMS

We live at the bottom of an ocean of air many hundreds of miles deep, and we must know what is going on in the air high above us before we can forecast the probable changes in the air at the earth's surface. Changes in weather are merely changes in air

and the causes of these changes occur in the upper layers of the atmosphere.

Information needed by meteorologists are the temperature, pressure, and humidity (humidity is the amount of moisture in the air) of the air at great heights, and also the speed and direction of the upper wind currents.

In fine weather the direction of upper winds and the strength at which they are blowing can be measured by small unmanned balloons.

By adjusting the amount of gas in the balloon, the balloon can be set to rise at a fixed speed, generally 500 feet a minute for meteorological work.

Attached to the balloon is a piece of thin metal. Radar impulses from the ground are reflected back from the balloon and picked up on the ground observer's radar screen. In this way the meteorologist can "see" the moving balloon even through cloud and continuously follow its progress up to great heights.

Balloons of this type indicate only the direction and strength of the wind. Details of temperature, pressure and humidity are obtained from a balloon called a radio-sonde, which broadcasts to the meteorologist readings from the instruments it carries. The radio-sonde was invented by Jules Idrac, a French meteorologist, in 1937.

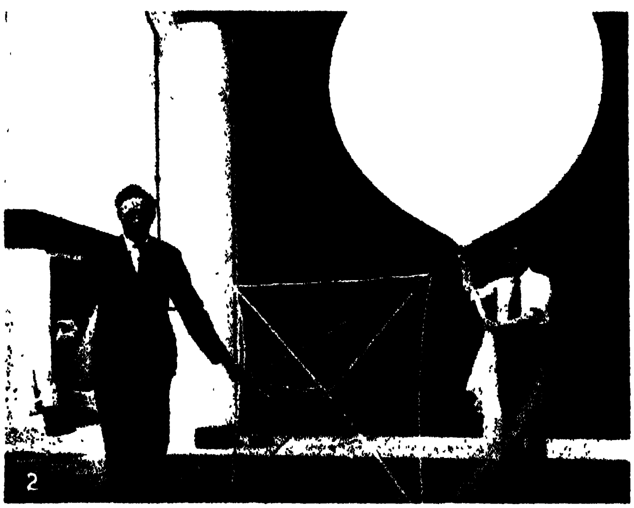
The gas-bag of the radio-sonde is inflated with hydrogen and is eight feet in diameter. It is launched from the ground through an upright tube, 15 feet high and nine feet in diameter, and rises at the rate of 1,000 feet a minute to a height of 10 or 12 miles.

Below the balloon is a frame aerial to which is attached a metal container holding a thermometer, barometer, and hygrometer, also a small radio transmitter. The container is 12 inches long and with its instruments weighs only three pounds. The thermometer records temperature, the barometer registers pressure and also the height of the balloon, and the hygrometer records the humidity of the air.

As the balloon rises, the changing conditions of the atmosphere cause the pointers on the instruments to move, and this movement turns cylinders in the tuned circuit of the radio transmitter. In this way the pitch of the notes broadcast by the transmitter changes in response to the changes in the air through which the balloon is passing.

Sound tables have been compiled of the different pitches from the balloon's transmitter according to the changes in temperature, pressure, and humidity. The balloon's transmitter sends out signals for a few seconds every minute and by listening in to these the meteorologist on the ground can measure the pitch of the notes, and with his sound chart convert them into temperature, pressure, and humidity readings. At the same time, radar plots the balloon's course to provide information about wind direction and speed.

While the balloon is rising, the gas in its envelope is expanding and eventually bursts the envelope, usually about 12 miles above the ground. The metal container with the transmitter and instruments then floats to earth by parachute, and in most instances lands without damaging them. Pasted to the container is a label offering a reward to anyone finding the instruments and returning them to the Meteorological Office.



In Great Britain there are 9 radio-sonde stations placed about 200 miles from each other. Balloons are released four times every 24 hours, and the information received from them is sent by teleprinter to the meteorological headquarters at Dunstable, where the weather forecasts you hear on your radio programmes are compiled.

Radio-sonde is used by the weather ships stationed in the Atlantic, and the information collected helps in compiling international meteorological forecasts.

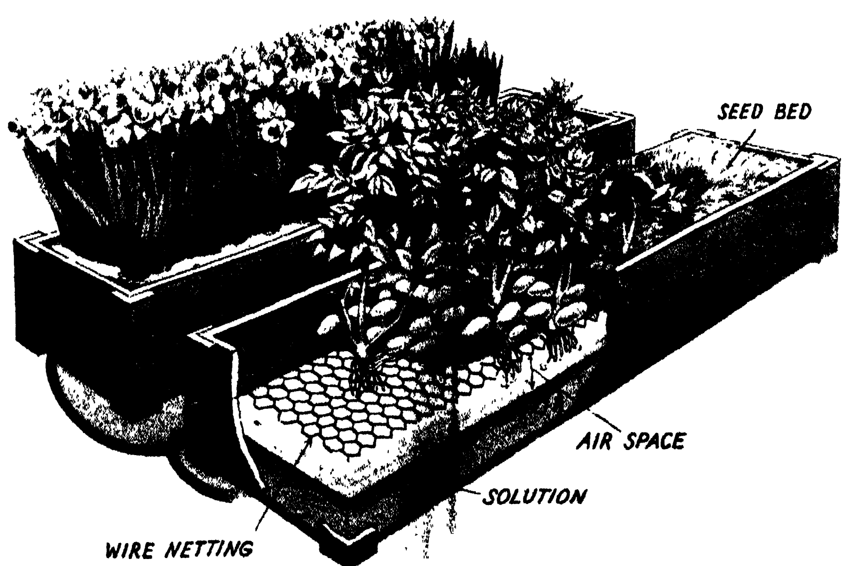
These photographs show how radio-sonde is used for forecasting the weather. In Fig. 1, technicians are adjusting the instruments and radio transmitter which the balloon will carry to a height of several miles. Fig. 2 shows the balloon with frame aerial. In Fig. 3 a meteorologist is watching on a radar screen the journey of a balloon ten miles above him. He is also reading the pitch of the notes from the balloon's transmitter

SCIENCE CAN FARM WITHOUT FIELDS

HYDROPONICS, which comes from a Greek word *hudros*, meaning water, suggests something very difficult and learned ; but it is only the impressive name given by scientists to the process whereby many boys and girls have grown watercress on a piece of damp cottonwool. Now chemists have found that a lot of plants besides watercress can be raised without planting seeds in the ground.

To achieve healthy growth a plant needs air, water and light, and it must be supplied with certain chemicals in the form of fertilisers. It was for long thought that fertilisers were less important than soil to plant growth ; that without soil the most efficient chemical fertiliser would fail to raise so much as a single shoot.

It is now known that the actual soil has little to do with plant growth. If the seeds or plants are supplied with a liquid containing certain chemicals, it is possible to raise healthy crops without any soil at all. Provided they are placed in a solution containing the chemical ingredients which make up a richly fertilised soil and are kept under the right conditions of light and temperature, seeds get all the food substances they require to build their tissues and reach healthy maturity without any soil.



This is the type of tray used for the experimental growing of plants without soil. Large crops are raised in the tiered cabinets described on this page.

Various methods are used for raising plants without soil. One of the simplest is to fill a shallow container to the brim with the nutrient fluid and then cover with cheese cloth that has been saturated in molten beeswax. The seeds to be sprouted are then spread over the cloth and covered with felt pads which are kept damp.

When they develop a root, the seedlings are taken from the cloth and placed in mesh trays laid over containers filled with the solution. The plants then continue growing until they are ready for harvesting. This process is suitable only for the experimental raising of hydroponically cultured plants, and for farming without fields on a commercial scale a system called cabinet culture is used.

Culture cabinets are of galvanised iron and are made in units. Each unit is eight feet square and six feet high. The interior of the cabinet is fitted with racks to hold 64 galvanised iron trays in four tiers, while below the tiers is space for a further 16 trays resting on the bottom of the cabinet in tiers of four. The cabinet is kept at a constant temperature of 80° F. by means of an electric or other heater.

Each tray is stamped with alternate rows of perforations and wells. The wells, which are the size and shape of thimbles, hold the germinating seeds. Above each tier of trays is a 50 gallon tank of the chemical fluid, which is evenly spread over the trays by a sprinkler.

Six pounds of seed are sown in each of the two lower trays of the four tiers, eight trays in all, resting on the bottom of the cabinet.

Solution from the tank seeps through the perforations in each layer of trays until it reaches the bottom trays filled with seeds. When the solution covers the lower trays the flow from the tank is automatically turned off, and the seeds soak for 24 hours.

At the end of 24 hours the seeds begin to sprout, and are transferred in their trays to the top rack of the cabinet. Eight more trays of newly-sewn seeds are then placed in the bottom of the cabinet and the nutrient solution again turned on.

This procedure is repeated every 24 hours until the tiers of trays are filled with seeds and shoots in various stages of growth. The little wells of seed fill with solution, then as they overflow the liquid drops through the perforations on to the next tray, and so on until the last trays are reached.

The wells hold just enough solution to feed the germinating seeds and growing shoots for the next 24 hours, so that there is no saturation except in the bottom trays of newly-sown seed. This prevents the growth of mould.

With grass or other fodder, the first sowing has grown to a height of ten inches on the eleventh day, and is at its most nourishing for the feeding of cattle. When removed from the trays the crop roots are found to have intertwined to form a mat an inch thick.

One cabinet holding 80 trays produces daily throughout the year 200 lb. of green crop. This is sufficient for the daily feeding of 20 cows or 100 pigs.

Fodder grown without soil has a particularly high food value. Ten pounds of grass grown in the cabinet are equal to 30 lb. of feed raised from the soil. Phosphate content of maize, for example, is increased by 600 per cent, and lime content by 300 per cent.

Bullocks and pigs fed all the year round on greenstuff grown in the cabinet have been brought to market weight much more cheaply than animals grazed on pasture land. Moreover, the animals reach market in better condition, and so realise higher prices.

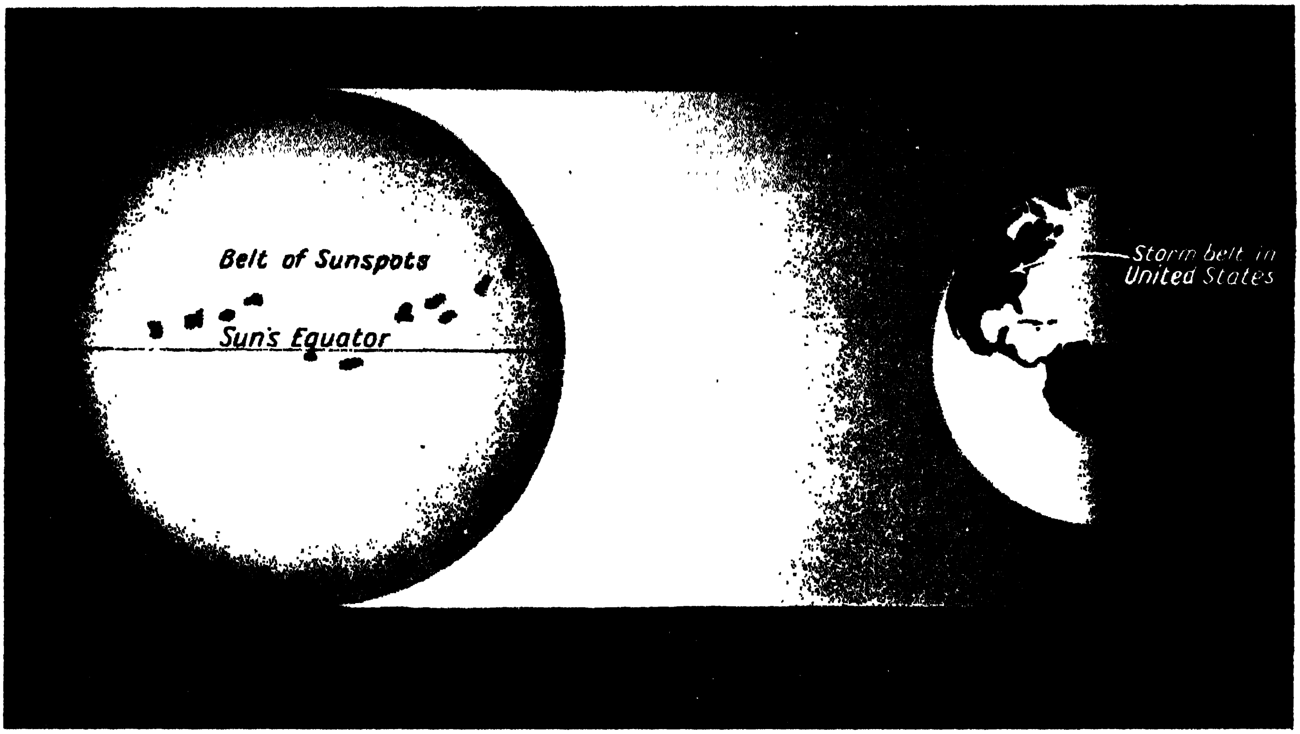
Although the cost of chemicals and equipment makes hydroponic cultivation on a small scale dearer than soil agriculture, large batteries of cabinets can produce crops at a price able to compete favourably with that of natural pasture. There is the additional advantage that crops can be grown to contain the maximum food value, and are available at all times of the year.

Hydroponic cultivation has been equally successful in the growing of domestic vegetables, the cabinets and process being the same as those used for grass and other feed crops. Vegetables so raised are equal, and in some instances superior, to vegetables grown in soil. Their mineral content is generally higher.

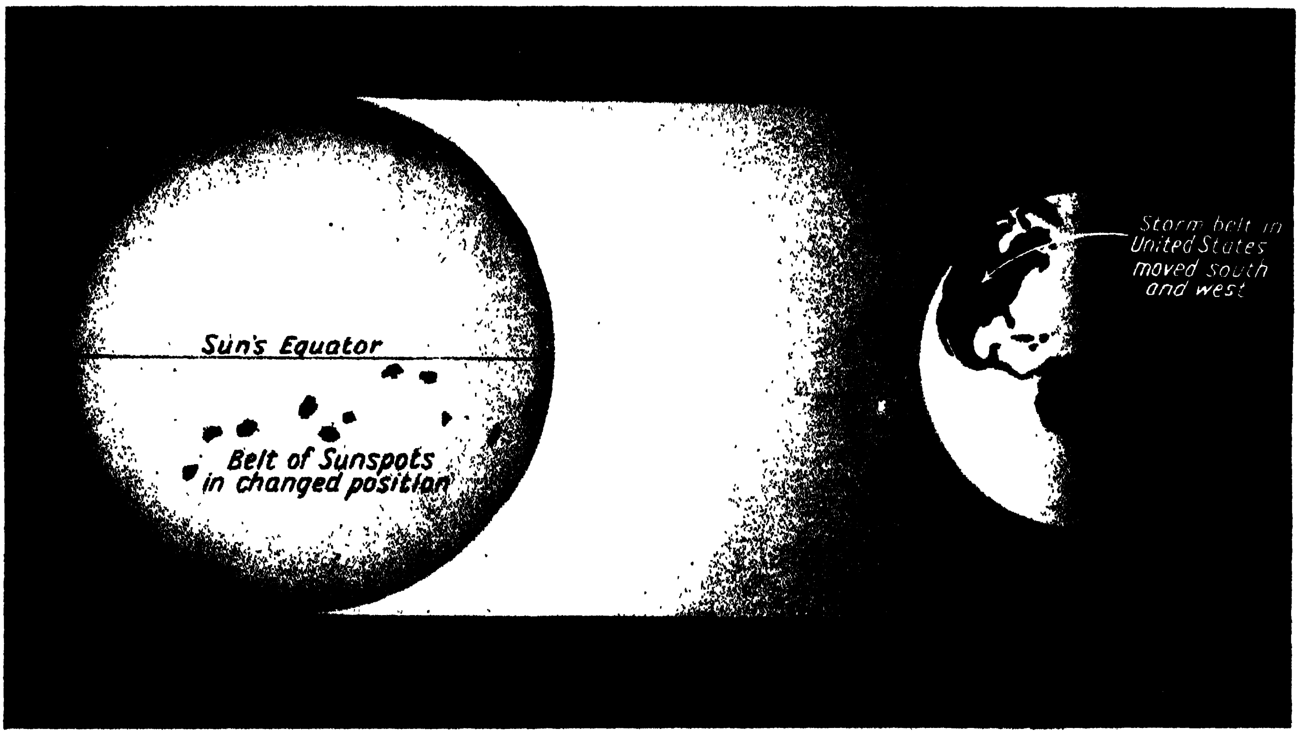
Fresh vegetables grown in cabinets replaced to a large extent the dehydrated varieties in the feeding of the Allied occupation troops in Japan after the 1939-45 War. There are also large-scale hydroponic market gardens in British Guiana and in China.

Hydroponic cultivation has even been developed to the point of permitting crops to be grown in artificial light, which can be adjusted and controlled in intensity to yield maximum crop production in the minimum of time, and independent of uncertain weather.

STORMS ON THE SUN & STORMS ON THE EARTH



It has long been known that the spots on the Sun's face, which are really whirling storms of gigantic size, affect conditions on the Earth. The displays of the Aurora and the variations of the magnetic needle correspond almost exactly with the variations in the sunspots. But researches by meteorologists in conjunction with the discoveries of astronomers, have shown that the sunspots have some influence on the Earth's weather. We are at present only at the beginning of the study of this subject, but already it has been found that storm areas on the Earth move as the Sun's spots change their position. In this picture we see a line of sunspots on the Sun's surface and a storm belt in the United States. This particular storm belt has been specially studied in connection with the position of the sunspots



In the two pictures on this page taken together the artist has tried to convey to our eye some idea of how the sunspots affect the weather. Researches over many years have shown that when the belt of sunspots changes its latitude or position on the Sun's face, the storm area in the United States also moves its position. We see by comparing this picture with the one above that as the line of sunspots has moved, so the storm belt in North America has moved farther south and west. Records of the appearance of sunspots have been kept for nearly a century and a half, but weather records for those years are not so continuous. It will be necessary for meteorologists to watch the weather conditions for many years to come and to compare them with the sunspot cycles before they can come to definite conclusions

WONDERS OF THE SKY

HOW SUNSPOTS AFFECT THE WEATHER

It is only in recent years that the influence of sunspots upon the Earth has been understood. It is known that electrical and magnetic conditions are affected by the sunspots, and now men of science have discovered that the spots have an important bearing on the Earth's weather conditions. Here we read some interesting and very remarkable facts about this important discovery

There seems to be no doubt that the Earth's weather conditions are to some extent, and perhaps to a large extent, affected by the spots appearing on the Sun's surface. These spots are the most conspicuous objects seen on the Sun, and appear quite dark against the bright disc.

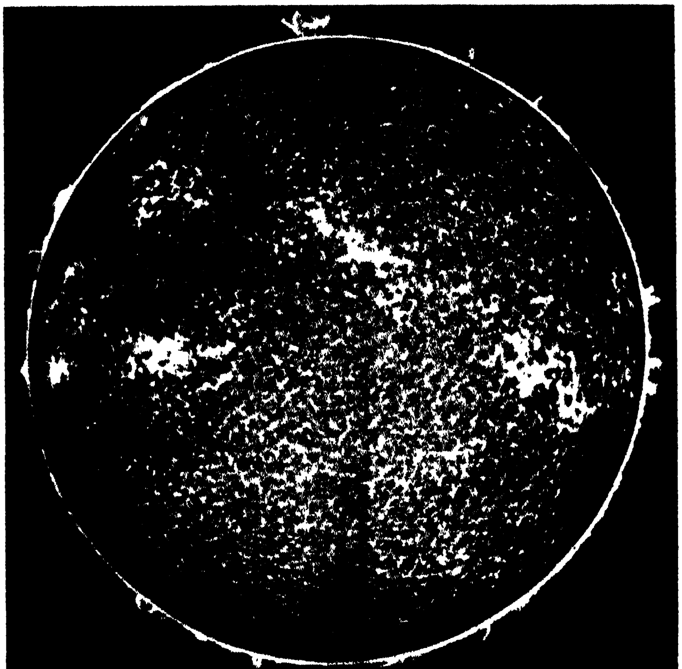
We read a good deal about these sunspots on pages 366 to 368, and we know that they have an important electrical and magnetic effect upon the Earth. This is described and illustrated on page 806.

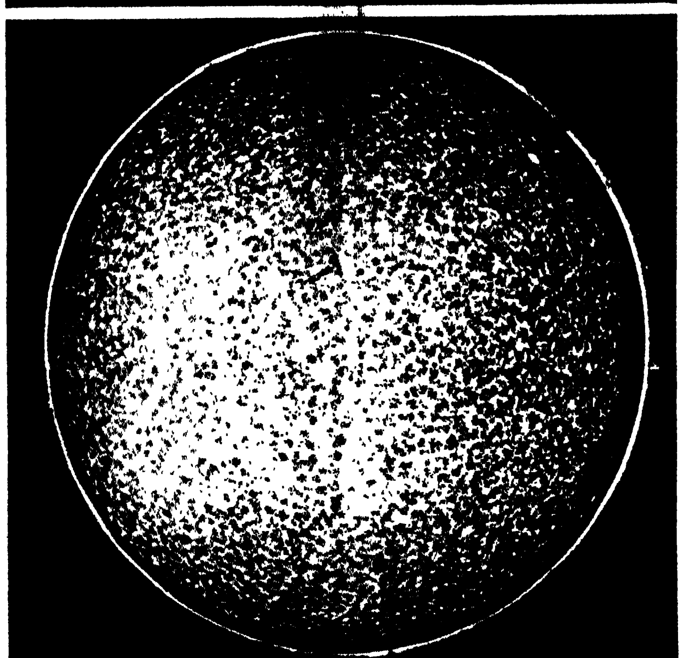
Solar "Freckles"

But the latest discoveries show that as the sunspots, or solar "freckles," as they have been called, change their position or latitude on the Sun's surface, so there is a change in the storm belt on our Earth.

The number of sunspots varies a great deal. Sometimes there are very many visible, while at other times the Sun's face may be almost clear. This variation is found to extend over regular periods of 11½ years.

The cause of the changes we do not know, but the patient and careful investigations of scientists have shown that the sunspot period is followed closely by a weather cycle on some parts of the Earth's surface. For one thing, the Sun is found to give three or four per cent. more heat at the period of sunspot maximum than it does when the sunspots are at their minimum. This is a curious fact, for while the temperature of most parts of the Sun's disc is from 6,000 to 10,000 degrees Centigrade, the temperature of a sunspot has been found to be only about 3,000 degrees.





These two photographs of the Sun's surface given here by courtesy of the Royal Astronomical Society were taken by means of calcium light. The upper photograph shows the maximum period of sunspots and the lower photograph the minimum. In some of the sunspots the dark part may be 50,000 miles across, and the lighter fringe 150,000 miles

It is known that sunspots are really gigantic storms on the Sun's surface, and what probably happens is that these have the same effect as when we take a poker and stir up the fire. The interior of the Sun is almost incredibly hot; Sir James Jeans believes that it is somewhere about forty million degrees. The vast disturbance caused by the storm or sunspot may stir up the surface and release some of this heat, thereby increasing the surface temperature.

Some scientists believe that it will one day be possible to forecast weather some time ahead from an examination of sunspots. Indeed, some attempts at this have already been made, and they have proved remarkably accurate.

Forecasting the Weather

Weather conditions on the Earth are, of course, caused by the different temperatures of the air at different parts. If the air in a certain region is for any reason warmed, it rises, and cold air rushes in from other parts. In this way winds and storms are caused.

Dr. C. J. Kullmer, after a long study of weather maps, shows that the storm tracks across the United States during the last 21 years made slight shifts to the south and west. These, he finds, correspond more or less to the shift in position of the sunspots on the solar disc. In other words, a shift in the latitude of storm tracks on the Sun means a similar shift of the storm belts on the Earth.

When this phenomenon is more fully studied, it may be possible to calculate storms years ahead.

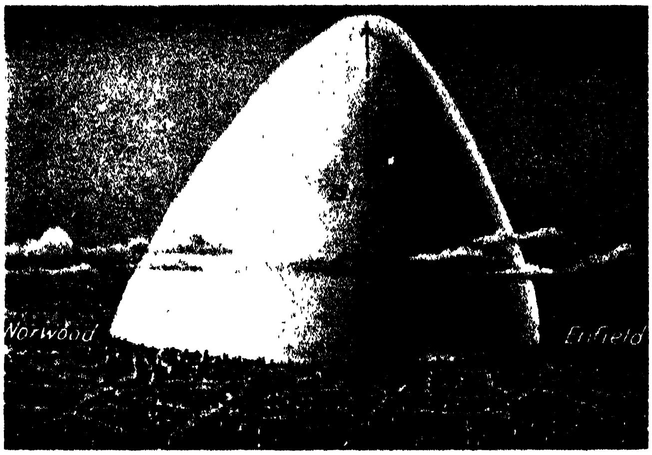
THE STRANGE MYSTERY OF A LITTLE WORLD

Travelling round the Sun in an orbit which sometimes brings it between the Earth and Mars is a small world, not more, it is believed, than 15 or 20 miles in diameter. This planetoid, or little planet, is called Eros, and its behaviour is so strange and its path so eccentric that it is regarded not as one of the ordinary minor planets that circle round the Sun between Mars and Jupiter, but as a little world that must be treated and studied apart.

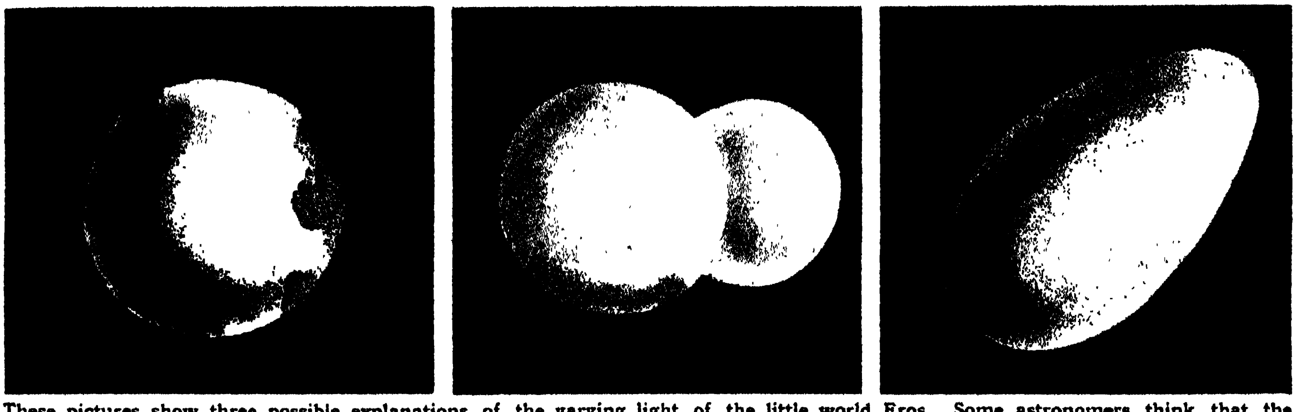
It was first discovered in 1898 on a photograph taken at Berlin, and then when earlier photographs taken in 1893, 1894 and 1896 were examined the small body was found on them also. Astronomers were able to work out its orbit, and were very much astonished to find that a great part of the orbit lay between the Earth and Mars, and not, as in the case of the other minor planets, beyond the orbit of Mars.

The orbit of Eros is very eccentric, so that when it is farthest from the Sun it is 165,500,000 miles away, and when it is nearest it is only 105,300,000 miles from the Sun.

But the most remarkable thing about this strange world is the variation in its brilliancy. At some periods it is very much brighter than it is at others, and astronomers are greatly perplexed in trying to account for this. The changes in brilliance are not only very extensive, but very rapid. When Eros is least bright it shows only one-third the light that it does at its brightest period.



If the little world Eros were suddenly to fall upon London it would reach from Enfield to Norwood and form a mountain about 15 miles high



These pictures show three possible explanations of the varying light of the little world Eros. Some astronomers think that the changing light is due to different parts of its surface reflecting the light to varying degrees, just as the oceans of our Earth look dark from Space and the lands light. Another explanation is that Eros consists of two little worlds which circle round one another and from time to time eclipse one another. A third explanation is that Eros is not spherical but egg-shaped, and presents sometimes its side and sometimes its end to the Earth. A fourth explanation suggests that Eros is not rounded in shape but angular

Such changes can be due only to one of two causes: either there must be rapid changes taking place on Eros itself, or its power to reflect light must depend upon its relative position with respect to the Earth and Sun. It is quite unlikely that the former is the cause of the changes and so the second must be the correct explanation.

But that does not take us very much farther. Why should the power of this little world to reflect the Sun's light change, and what alters its relative position with respect to the Earth and Sun?

Several explanations have been given, and they are illustrated on this page. One idea is that the different parts of the surface of Eros reflect the light very unequally. It is suggested that there are light and dark markings on its surface, and that these are arranged something like the continents and oceans on the Earth's surface. If the Earth were viewed from Space the continents would appear very light and the oceans very dark.

Another explanation given by the French astronomer André is that the little planet is really a pair of twin worlds, which revolve round one another. When one body eclipses the other from our point of view the light is reduced, and when both little worlds face the Earth with the Sun shining on them the light is naturally increased.

Still another explanation is that Eros is not really spherical but egg-shaped, and that when it is seen sideways it reflects much more light than when it is seen endwise. Sideways it would present much more surface to the Earth than when the end was seen. At present no one can say what is the true explanation. It may be one of these, or it may be something entirely different and unsuspected.

Apart altogether from the variations of brilliance which have been described, and which seem to occur about every five hours, Eros varies a great deal as seen from the Earth at different parts of its orbit. When it is nearest to the Earth it is only 13,500,000 miles away, but at its farthest it is 260,000,000 miles away. This enormous difference in distance of course affects its appearance. When nearest it is about 400 times as bright as when it is at its remotest point.

It is only when Eros comes near that it can be studied. In 1900 it came within 30,000,000 miles of the Earth, and that was its first appearance after discovery. In 1931 it came within 18,500,000 miles of the Earth, but astronomers are looking forward to the time when it will pass at its nearest, namely, 13,500,000 miles.

To account for the variations in brightness some astronomers have even thought that Eros may not be round at all, but have faces something like a rough stone from the road. The different sizes of these faces might account for the variations in brilliance. The strange orbit in which Eros makes its journey round the Sun can be seen in the diagram on page 662, which shows the orbits of the Earth, Mars and Eros, that of the latter crossing that of Mars.

A SICK GENERAL WHO WON AN EMPIRE

The winning of the British Empire is often spoken of as a great romance. But it would be more correct to describe it as a series of romances. No more exciting story could be told than that of Clive and India, but equally thrilling is the winning of Canada by General Wolfe, who at the time of his brilliant victory was not only an exceedingly young man to be in charge of a great enterprise, but was a very sick man, and throughout the campaign suffered agonies of bodily pain Here is the story

FRANCE and England were rivals for mastery in North America, exactly as they were in India, but their methods were different. The English settled in large numbers, started industries, and began to build up a nation. The French, on the other hand, emigrated from their motherland in far smaller numbers, and relied more upon establishing forts and conciliating the natives to become their allies. The English also had native allies, although the tribes in league with the French were far more numerous. These Red Men used to be encouraged by their European friends to prey upon the white settlers of the other side, and many cruelties in the way of burnings, killings and scalpings took place.

There were always great rivalries between the English and the French in North America, and when France and England were at war these rivalries developed into open hostilities.

During the Seven Years' War the French and English fought on opposite sides, and the war having extended to North America, it was decided by the English Government to make an attempt to dislodge the French from Canada, where they held strong positions, particularly at Quebec, their capital.

A Clever General Wanted

It would be tedious to describe the campaign that resulted, unfortunately for England. The British generals were not brilliant, and it looked as though the French would retain their mastery of the rich northern lands.

At last the elder Pitt, who had come into power in England, decided to make a strenuous effort to win Canada. The French general in command there was the Marquis de Montcalm, a skilful and intrepid officer. If he was to be beaten an English general of more than ordinary ability and daring would have to be sent out to lead the British forces. But who was available? British generalship at this period was certainly not distinguished by brilliance or originality, and practically all general officers were selected not for their ability but because of their aristocratic connections.

William Pitt, the elder bearer of that name, a truly great statesman decided to break away from this tradition, and he selected as the general who should make the attack on Quebec a young man named James Wolfe, who had no high social standing, but had shown himself possessed of much ability, enthusiasm and industry in his work. He was only 33 years of age, which was extraordinarily young for a commander at that period, but Pitt determined that he should lead the expedition to Quebec, which was contemplated.

There were to be two other expeditions in Canada. One, under General Prideaux, was to advance against Niagara, capture that fortress, and then, crossing Lake Ontario, threaten Montreal. The other, with the main army of 12,000 men under the command of General Amherst, was to attack Ticonderoga, on Lake Champlain, and then push forward to join with Wolfe in his operations at Quebec.

General James Wolfe. From the painting in the National Portrait Gallery

Wolfe's task, however, was the most difficult, and the whole of his force was to consist of only 8,000 men.

Who was this young general who was to leave such a mark upon the history of his time, and to prove one of the founders of the British Empire? He was the son of a general who had fought in the wars of Marlborough, and on retiring had rented the vicarage at Westerham, in Kent. There, in 1726, James Wolfe was born, and at fourteen he entered the army.

He was present at the battles of Dettingen and Fontenoy, and joined the force that returned to England from the Continent and was sent north to oppose the Young Pretender. Wolfe was on the staff at the battle of Culloden, and he was lucky to escape unhurt, for his regiment was the one which suffered most in the battle. There is a story that the Duke of Cumberland after the battle told Wolfe to shoot a wounded Highlander, and that Wolfe refused.

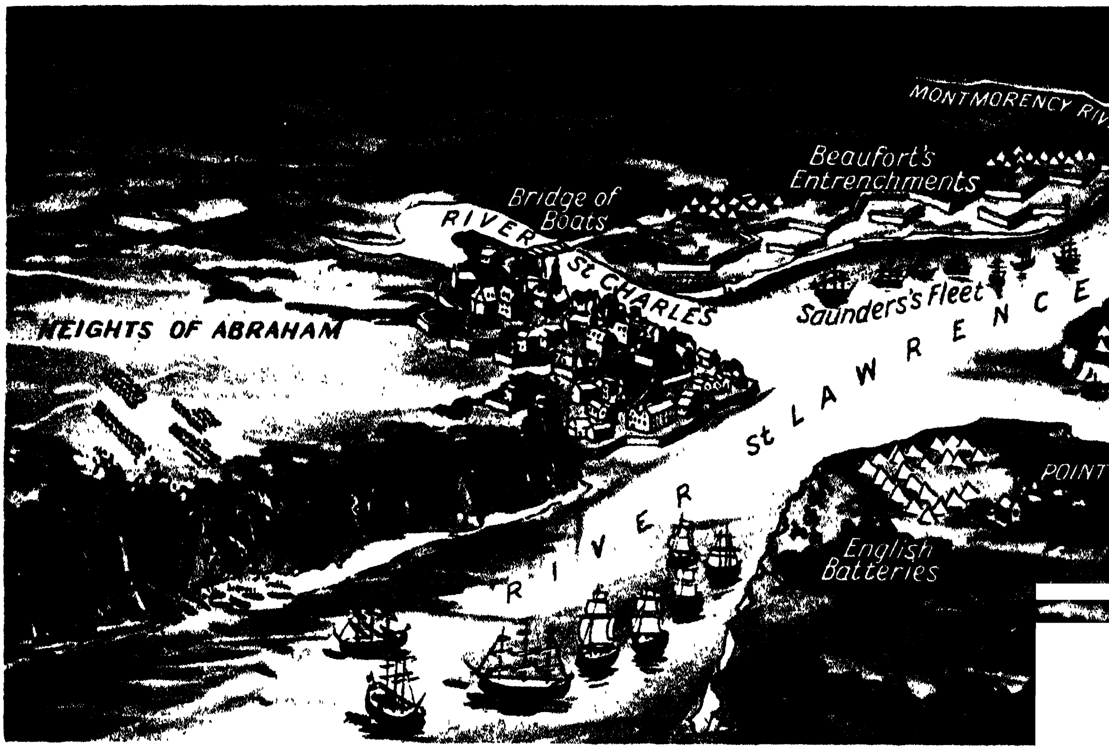
After being almost continuously on active service Wolfe was sent, in 1758, to America as a brigadier-general, to take part in the siege of Louisbourg. The place surrendered, and Wolfe was described as showing great merit, spirit and alacrity.

Then he returned to England, but wrote to Pitt offering his services in America "particularly in the River Lawrence, if any operations are to be carried on there"

Ill Health and Suffering

At this time Wolfe was a great sufferer from ill-health. He had a very painful complaint, and was eaten up with rheumatism Canada was the last place he should have gone to from the health point of view. He cared nothing, however, for his own personal welfare, but being a great patriot, wanted to do the best he could for his country. So he accepted the appointment with enthusiasm.

Wolfe never shone in society. He was shy of disposition and not attractive in appearance. His hair was red, and he made no attempt to follow the custom of the day and powder it. He realised that he could never do his best except in unusual circumstances. "My nature," he wrote to his mother, "requires some extraordinary events to produce itself. I want that attention and those assiduous cares that commonly go along with good nature and humanity. In the



A bird's-eye view of Quebec and the surrounding country, showing how the English attacked and the French defended the city

common occurrences of life I own I am not seen to advantage."

Referring to his appointment he wrote: "The backwardness of some of the older officers has in some measure forced the Government to come down so low. I shall do my best and leave the rest to fortune, as perforce we must when there are not the most commanding abilities."

Late in February, 1759, Admiral Saunders, with a fleet, sailed from Spithead for Canada, carrying Wolfe, his stores, and a few troops. The bulk of the army for the capture of Quebec was to be gathered in Canada. The voyage was a rough one, and it was May before Wolfe landed at Halifax in Nova Scotia, where the young general's American troops had been collected.

The soldiers he had taken from England were perfectly disciplined and of the very best material, and although Wolfe's force was weak in numbers it was efficient in quality. "If valour can make amends for want of numbers," he wrote to Pitt, "we shall succeed."

Of course, in the early part of the year the St. Lawrence is blocked by ice, but on the first of June Admiral Saunders, with Wolfe and his army, started from Halifax, the bands playing "The Girl I Left Behind Me" as they set out, and the men cheering heartily. At the mess tables the officers had only one toast: "British colours on every French fort, pos and garrison in America."

The admiral's fleet consisted of 22 ships of the line, beside the transports, and by the 14th of June they had entered the St. Lawrence River.

Very little was known by the English at that time about this river, and pilots were badly needed, but how could they be obtained? French subjects could hardly be expected to help. Their services, however, were secured by a ruse.

Some of the British vessels going near the shore ran up French flags, and thereupon numbers of the country people rowed out and went on board. Their surprise when they found that the ships were English can be imagined. In this way a pilot was secured.

A City Well Defended

While the British expedition was thus nearing Quebec what was Montcalm doing? Well, he was not idle. It had always been maintained that no expedition strong enough to threaten Quebec could ever navigate the St. Lawrence River, and it was believed that three or four thousand men could hold the city against any possible force that could come against it. Instead of that number there were 16,000 French troops under arms, and Montcalm's plan for the defence of the city was well thought out.

As can be seen from the picture plan given on this page, Quebec stands on a steep promontory on the north-west bank of the St. Lawrence, with the Heights of Abraham, named after an old French pilot, on one side, and across the St. Charles River on the other side a long ridge stretching for six miles to the Montmorency River. It was situated at the junction of the St. Lawrence and Charles Rivers, and was defended at its back by a forest.

The Heights of Abraham were regarded as quite unscalable, and the ridge between the Charles and Montmorency Rivers was strongly fortified and entrenched. In fact, the position of Quebec was regarded as impregnable.

Wolfe, however, was determined to take the city. But how was he to do it, in the face of a French army twice the size of his own, possessing full knowledge of the country, the sympathy of the natives and settlers all round, and with an able general in command? Knowing the situation, no one but a Wolfe could have dared to think of success.

The British fleet, to the astonishment of the French, sailed safely up the river and the invading army was landed on the Isle of Orleans on the opposite side of the river, facing the French entrenchments.

Here the fleet anchored, and the next night Montcalm tried the plan that Drake had found so successful in causing panic among the ships of the Spanish Armada. He sent a number of fire-ships down the river towards the anchored fleet. They were floated down quietly, and the matches were not applied till the hulks were almost upon the fleet.

Then suddenly they burst forth into flame, explosives went off with terrifying sounds, and the British sentries, the only people awake, were panic-stricken and rushed off to the sleeping camp to give the alarm. As the flames shone out and the grapeshot and bullets fired from guns on the fireships crashed through the trees, the suddenly awakened army almost lost its nerve.

The sailors, however, were not frightened like the soldiers. In fact, they treated the matter rather as a joke, and setting out for the fire-ships, grappled them and towed them ashore, where they could do no harm Montcalm's plan had failed.

A Proclamation to the People

James Wolfe was a great fighter, but he was also a great gentleman. He issued a proclamation to the civilian population, saying: "We are sent by the English King to conquer this province, but not to make war upon women and children, the ministers of religion, or industrious peasants. We lament the sufferings which our invasion may inflict upon you, but if you remain neutral we proffer you safety in person and property, and freedom in religion. We are masters of the river; no succour can reach you from France. General Amherst, with a large army, assails your southern frontier. Your cause is hopeless, your valour useless. Your nation has been guilty of great cruelties to our unprotected settlers, but we seek not revenge. We offer you the sweets of peace amid the horrors of war. England in her strength will befriend you. France in her weakness leaves you to your fate."

Unfortunately, however, the peasants would not remain neutral, but did all they could to assist the French and harass the English.

Wolfe now made a survey of the situation, and realised the enormous difficulties of his task. He had, of course, been told to expect the help of Amherst, but he knew only too well that that general was not noted for quick movement in the field.

Wolfe decided that he must occupy Point Levi, an elevated shore of the river facing Quebec. He did so, at once, meeting with only slight resistance, and then getting his guns into position began to throw shot and shell into the lower city. It is said that Montcalm had wanted to occupy this position, but that the French Governor, Vaudreuil, who was his superior, forbade it on the ground that the upper or most important part of the city could not be reached by gunfire from that bank. He soon found that he had been wrong and Montcalm right. But it was too late, and shot and shell poured upon the city, doing much damage. Houses, churches and monasteries fell beneath the bombardment, and even the great cathedral, the pride of Quebec, was reduced to ruins.

All this time Wolfe was suffering terribly in body, but he was here, there and everywhere inspiring his men and putting zest into the attack.

Messages passed between the two sides under flags of truce, and one which the French despatched said: "You may destroy the town, but you will never get inside it."

"I will take Quebec," replied the young general, "if I stay here till November."

It must of course be understood that when the Canadian winter started, anything in the way of serious military operations in such a situation would be impossible, and the winter often starts very early It was now July, and if the English were to capture the French capital it must be done in the next few weeks.

Wolfe decided that he would make an attempt to storm the Beauport lines, that is, the French entrenchment opposite the Isle of Orleans.

At one place the Montmorency River could be forded at low tide, although the landing place on the opposite bank was difficult. Wolfe, however, decided to make the attempt. Two thousand men under General Townshend were to ford the Montmorency, and at the same time Wolfe with a similar number of men was to approach the entrenchments direct in flat-bottomed boats, and land on the narrow flats beneath the fortified ridge, which looked down upon them.

A British frigate was brought to the place to keep up a fire on the French lines, and a number of English batteries fired across the Montmorency River.

Townshend and his men crossed the ford successfully, and Wolfe, after some difficulty, landed and captured an outlying redoubt. But before he could direct any united action between the two British forces something happened which upset the whole plan

The Grenadiers and some American troops, less than a thousand strong but all veterans, without receiving any orders from their officers, and without any military formation, suddenly rushed up the slippery slope towards the fortifications, where were cannon and 3,000 marksmen, with another 10,000 men ready to lend support

Rebuking the Troops

It was, of course, utter madness. By no possible means could the attack have succeeded, and when the French opened fire the slope was covered with British dead and wounded. Altogether 443 men were killed The British had to retire and Wolfe's attempt on the Beauport entrenchments had failed

The next morning he addressed the men who had made the insane attack, condemning them for their "impetuous, irregular and unsoldierlike proceeding," and asking them if they supposed that they alone could beat the whole French army.

After this the English remained almost inactive right through the month of August, and Montcalm was perhaps entitled to consider himself and his city safe He even allowed 2,000 auxiliary troops to leave for their homes to gather in the harvest

A thousand of Wolfe's men were in hospital, either sick or wounded News arrived that Amherst, although he had been successful in taking Ticonderoga, was unlikely that season to be able to get through or render any assistance Prideaux had captured Niagara, but he could not help Wolfe, and anyone but the young English general would have despaired and given up the campaign for that year

He wrote to his mother, however, hopefully, saying of Montcalm: "The old fox has a large army of bad troops, while I have a small army of good ones"

It should be explained that a very large part of Montcalm's army, while no good for fighting in the open, consisted of skilled marksmen who were deadly behind entrenchments.

The situation was getting hopeless for the English and then, to make matters worse, Wolfe fell really ill. His painful complaint grew worse, and for

Wolfe, in a low voice, recited Gray's "Elegy Written in a Country Churchyard," adding, "Gentlemen, I would rather have written those lines than take Quebec

a week he lay sick of a fever, and helpless His physical pain was increased by his mental agony at the thought of failure. He himself had become the sole inspiration of his army His men adored him, but if he were to be prostrated on a bed of sickness what could happen but failure? By the first of September, however, he had sufficiently recovered to get up

Twenty British ships had been sent up the St Lawrence beyond the town, past the Heights of Abraham, but the shore here was found to be strongly fortified everywhere. Quebec, however, drew its supplies of food from this area, and anything that could harass the French ships up there would assist Wolfe and hinder Montcalm

On September 3rd Wolfe moved the whole of his forces which had been on the banks of the Montmorency to his camps on the Isle of Orleans and Point Levi

There is no doubt that at this time he had decided upon his plan of attack the plan that was to prove so brilliantly successful But he wanted the French to get no inkling of it, and so in those early days and nights of September he did all he could to harass and confuse the French, giving the impression he was going to do something, but what they could not conceive

Bewildering Tactics

He paraded his troops in camp, he made demonstrations by loading the troops into boats and taking them here and there, he caused the warships to move up and down the river, he kept up the bombardment from his batteries on Point Levi, and as all these movements could be seen from the city on its lofty perch, the French must have been bewildered and very worried.

Then on September 5th Wolfe was again laid low on a bed of sickness. His complaint and his rheumatism, together with fever and the great mental strain under which he was labouring, would have killed any man with a less indomitable spirit. But Wolfe was determined to take Quebec

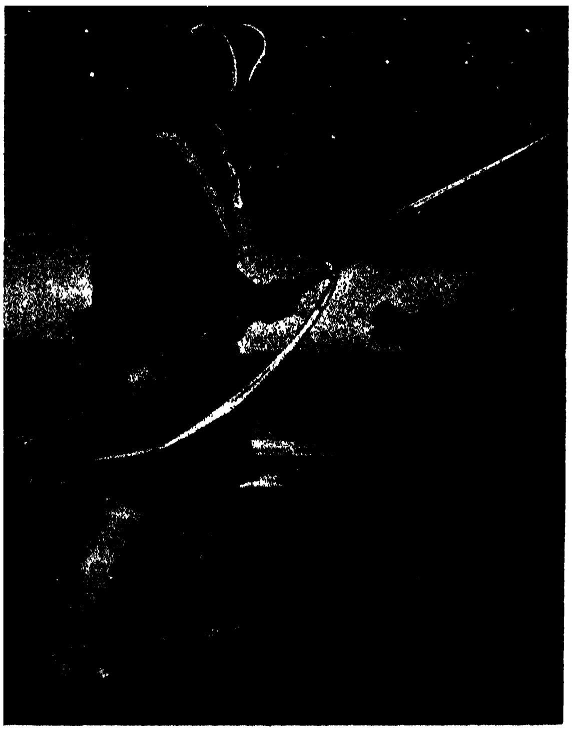
"Patch me up sufficiently for the work in hand," he implored his doctor, "and after that nothing matters"

The next day, although a sadly sick man, he struggled up from his bed and led a march of his men 4,000 strong up the south bank of the river. At a certain point they were taken on board the boats of the fleet and then moved up the river as though about to make an attack.

Another feint was made at the mouth of the Charles River. It must have been very confusing and harassing to the French But still, time was in their favour, and it seemed as if the idea that Quebec was impregnable to attack was to prove true after all.

And now at last Wolfe decided to carry out his plan He had seen by means of a telescope, while examining the Heights of Abraham from the opposite bank, a little path that ran with a steep slope up the face of the wooded precipice. It is said that an English officer, who had long been held a prisoner at Quebec, had escaped and drawn Wolfe's attention to this path Whether that be the case or not, Wolfe, after careful consideration, believed that a body of picked men could scale the heights, and plans were accordingly laid to make the attempt

If the picked men could reach the top and overpower the few French soldiers left to keep watch there, the general believed that the rest of the army could scramble up and reach the heights when Quebec would either be at his mercy, or the French army would have to fight In the open field he believed there would be no doubt about the result, even though the French forces might be in overwhelming numbers.



As the boats turned in towards the shore a challenge was given by a French sentry: "Who goes there?"

On the morning of September 7th Wolfe's army sailed up the river beyond the Heights of Abraham to a place where a French force was entrenched. The vessels came to anchor, and in the afternoon opened fire, while boatloads of soldiers rowed up and down as if busily engaged in looking for a place at which to land.

This was only a feint on the part of Wolfe, and it had the effect of deceiving the French commander, Bougainville, who supposed the English wanted to land up the river far beyond Quebec. Nothing, however, happened, and for the next two days the rain poured incessantly The English troops, crowded in their ships, suffered a good deal, and it was therefore decided to land about half of them on the south shore of the river, where they could dry their wet clothing and blankets.

For the next few days the British ships drifted up the river with the flood tide and down with the ebb tide, passing and repassing between Quebec and the French force under Bougainville. The French were greatly perplexed, always expecting an attack, and never knowing where it was to be made.

On September 12th the troops that had been landed were again taken on board, and Wolfe issued a general order to his forces which is worthy to rank with Nelson's order: "England expects that every man will do his duty"

Battle Orders

"The enemy's force is now divided, great scarcity of provisions in their camp, and universal discontent among the Canadians. Our troops below are in readiness to join us. All the light artillery and tools are embarked at the Point of Levi; and the troops will land where the French seem least to expect it. The first body that gets on shore is to march directly to the enemy, and drive them from any little post they may occupy; the officers must be careful that the succeeding bodies do not by any mistake fire on those who go before them The battalions must form on the upper ground with expedition and be ready to charge whatever presents itself. When the artillery and troops are landed a corps will be left to secure the landing-place, while the rest march on and endeavour to bring the Canadians and French to a battle. The officers and men will remember what their country expects from them, and what a determined body of soldiers inured to war is capable of doing against five weak French battalions mingled with a disorderly peasantry."

Wolfe had altogether 3,600 officers and men with him on the ships. He sent orders that as many as could be spared should march along the south bank of the river from Point Levi, in the island of Orleans, after nightfall, and await orders at a spot that was named. Altogether, about 1,200 carried out this order, so that the total available army was 4,800 Wolfe meant with these to climb the Heights of Abraham.

Admiral Saunders was to range his fleet along the Beauport shore and to lower boats and fill them with sailors, marines, and the few troops that were left. The ships were then to signal to one another, and the cannon were to be fired as though preparing a way for landing

Saunders certainly assisted in the plan admirably. The firing that was carried on in the river above Quebec was regarded by Montcalm as only a feint, and he believed that a serious attack was to be made on the Beauport entrenchments. He, therefore, gathered the bulk of his army in that part and awaited the English.

While in the fleet with Saunders all seemed uproar and excitement, as though it were about to attack, the danger to the French was really ten miles away, where the other British ships lay silent at their anchorage. But all the men on board knew that that night a blow was to be struck, though where had been kept secret from all but a few officers.

Volunteers were called for to make a desperate venture, and it was said that if any survived they could depend upon it that they would be recommended to the General. Of those that came forward 24 were selected

Well-Laid Plans

Late in the evening thirty large boats which lay moored by the side of the ships were filled with troops, and these held altogether 1,700 men. The rest of the army remained on board the ships The 24 volunteers were in the first boat. Bougainville could see that something was going on, but gathered that he himself was to be attacked, and in order to add to his deception some of the boats were allowed to drift up the river with the tide as if to land in the higher reaches.

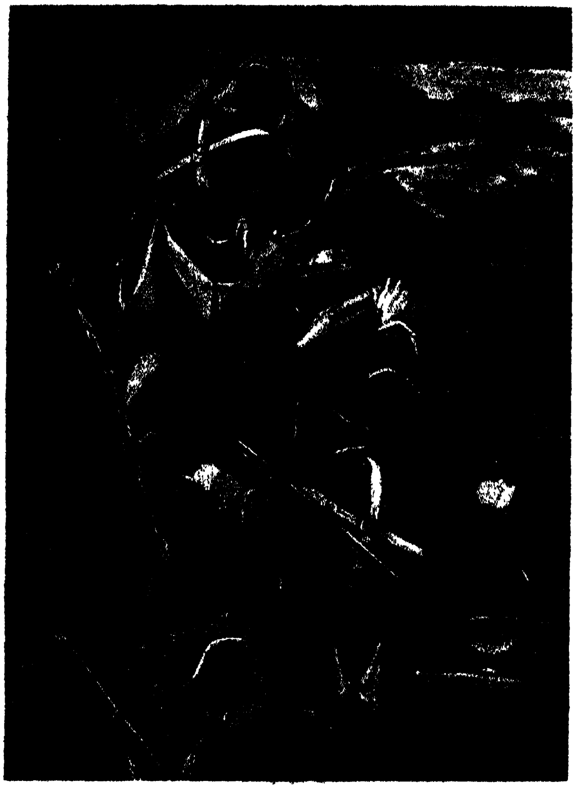
Wolfe's plan was that under cover of darkness the boats should go down silently under the shadow of the northern shore, and that the 24 volunteers should scale the Heights of Abraham Then, when they had silenced any sentinels that might be found, the rest of the army should scramble up as best it could and form up on the heights above.

Circumstances now began to work in favour of Wolfe. It has been explained that all the food supplies of Quebec came from the upper part of the river, and two deserters from Bougainville's camp brought news to Wolfe that at ebb-tide that night a convoy of provisions would come down the river to the city.

The risk was to be taken of sending the food by water because of the difficulties of land transport. The French had often allowed their food boats to drift down in the darkness under the shadow of the northern shore, and generally they had passed in safety.

Wolfe saw at once that if he sent his boats down in advance of the French boats they would be mistaken for the food convoy, and probably get to the place of landing undetected.

Everything was now in readiness for the great attempt. Wolfe, who sat in the cabin of the *Sutherland*, talking to a former schoolfellow of his, John Jervis, afterwards the famous Admiral Earl St. Vincent, told that officer that he expected to die in battle the next day. Taking from his bosom a miniature of his fiancée, he gave it to Jervis with a request that he would return it to her if the day should end fatally



The volunteers climbed up the Heights as silently as they could, closely followed by other soldiers

About two o'clock in the morning the tide began to ebb, and a fresh wind blew down the river. Everything was favourable to the enterprise. The signal was given by raising two lanterns to the main top shrouds of the *Sutherland*. At once the boats cast off and slowly drifted with the current.

Bougainville saw the British fleet drift down-stream, but did not take the trouble to follow them, thinking they would return with the next tide to attempt their landing where he was encamped. For two hours the procession of boats went on. The stars were visible, but there was no Moon, and the darkness was enough to hide the boats

Wolfe himself was in one of the foremost boats, and near him was a young midshipman, John Robison, who later became a professor in Edinburgh He tells us that as the ships drifted along, Wolfe in a low voice recited Gray's "Elegy Written in a Country Churchyard," adding, "Gentlemen, I would rather have written those lines than take Quebec."

It must have been a dramatic and prophetic moment as the young general repeated the words:

> The boast of heraldry, the pomp of power,
> And all that beauty, all that wealth, e'er gave,
> Await alike th' inevitable hour
> The paths of glory lead but to the grave

As the boats turned in towards the shore a sharp challenge came from a French sentry: "Who goes there?"

"France," answered a Highlander, who could speak French fluently

"Of what regiment?" came the reply.

"The Queen's," returned the Highlander, who knew that part of that corps was with Bougainville.

The sentry, who had been informed that a food convoy was to pass, was satisfied, and did not ask for the password

The Silent Climb

A little lower down another sentry challenged the boats, and in reply the same officer said in French: "Provision boats. Don't make a noise or the English will hear us" As an English sloop was anchored not far off the sentry said no more and let the boats pass

Soon they rounded a headland and came to the landing-place Wolfe was one of the first to leap ashore. The 24 volunteers climbed up as silently as they could, closely followed by other soldiers They reached the top in safety, and saw through the darkness a group of tents not far off They immediately rushed at them A French officer leaped from his bed and tried to run off, but he was shot in the heel and captured. Some of his men escaped, but two or three were caught

Wolfe and his men were listening intently at the foot of the forbidding rock for some sound that should tell them the enterprise had succeeded Presently their strained ears heard musket shots and loud hurrahs. Wolfe knew at once that his men had mastered the position. Word was given, the troops leaped from their boats and scaled the heights, some here, some there, assisting themselves by clutching at the branches of the trees and bushes. Their muskets were slung over their backs so as to leave both hands free.

Wolfe, although weak, managed to

drag himself up with the others, and when the morning began to dawn a considerable force of Redcoats had formed up on the plateau

Then cannon were heard booming. The sounds came from a French battery that had begun to fire on the English boats and vessels following up at the rear. Wolfe sent some of his men to silence the battery.

The British troops continued to land and climb the heights. As fast as a boat emptied it returned to the ships to take on more troops, and by daylight Wolfe's battalions were all drawn up on the Heights of Abraham. The most dangerous part of the enterprise had been carried out successfully.

An Astonished General

When Montcalm was informed that the English army was on the Heights of Abraham he could not believe the story. Then he thought that a few men must have appeared there merely as a feint, to draw him from the Beauport lines. However, he rode forward and his eyes convinced him of the truth. He was staggered. "I see them," he said, "where they ought not to be, but if we must fight I shall crush them."

Gathering as many troops as he could muster he hurried across the St Charles River by the bridge of boats. The English were now advancing. They had no cavalry and only one cannon, but Wolfe had inspired them with ardour and they were determined to conquer or die.

Montcalm had mingled his Canadian regiments with his French troops, and some think this was a mistake. He filled the thickets and copses with 1,500 of his best marksmen, who kept up a constant fire, which drove back the English pickets in confusion.

Wolfe, however, regardless of his own safety, moved along the line encouraging his men to stand firm and instructing them to reserve their fire, no matter what happened, until the enemy should be within forty yards of the muzzles of their muskets.

The troops obeyed him to the letter. Although many of them fell mortally wounded, the regiments remained immovable while the French were coming on. Wolfe himself received a ball in his wrist, but he tied his handkerchief round the wound and never flinched.

At last the French were within forty yards, and then the British fired a well-aimed volley. It did its fatal work. When the smoke had cleared away large numbers of the enemy were lying on the ground, many had fled, and those who remained wavered.

"See How They Run!"

Wolfe darted forward, cheering on his men, and then a second ball struck him in the groin. He was in agony, but, concealing his anguish, he continued to advance and give orders. At last a third shot pierced his breast, and he fell to the ground.

Men carried him to the rear, where it was soon clear that he was dying. From time to time he tried to lift his head to look at the field of battle. Then his eyesight began to fail. For some moments he was motionless, the only sign of life being his heavy breathing.

Suddenly an officer who was standing by exclaimed, "See how they run!"

"Who run?" asked Wolfe eagerly, raising himself on his elbow.

"The enemy," answered the officer "they give way in all directions."

"Then God be praised," said Wolfe, "I shall die happy."

With these last words he fell back and expired. His death was remarkably like Nelson's, and he has often been called the Nelson of the army.

About the same time the Marquis de Montcalm was also struck by a musket ball while trying to rally his men. He was carried back into the city, where he expired the next day.

When told that his end was near he answered, "So much the better. I shall not then live to see the surrender of Quebec."

Joy and Grief Together

The city fell the next day, and although for a time the English were themselves besieged by a French force, they soon gained the upper hand. Wolfe's daring victory on the Heights of Abraham had given an empire to Britain, and practically ended the French rule in North America.

When news of the victory reached London there were strange scenes. Exultation at the success was blended with sorrow for the young hero's loss. An eyewitness says: "Joy, grief, curiosity, astonishment were painted on every countenance. The more they inquired the higher their admiration rose."

Everyone, rich and poor alike, wore mourning for Wolfe, and when his remains reached Portsmouth they were landed amid the highest honours. Flags everywhere floated at half mast, and minute guns were fired. It seemed almost like the death of a sovereign.

Years afterwards in the Government grounds at Quebec was erected an obelisk sixty feet high, with the word "Wolfe" on one face and "Montcalm" on another. It was a magnificent joint tribute of two races to two gallant soldiers.

The death of General Wolfe on the Heights of Abraham, at Quebec, in the moment of victory. From the painting by Benjamin West

AN ANIMAL WITHOUT A FRIEND

If a universal vote were to be taken as to which of all the larger animals was the ugliest and most repulsive, there is little doubt that the crocodile would head the poll. It is both a bad-tempered and a dangerous beast, and here we read many interesting facts about its life and habits

NOT only is the crocodile unattractive in form and ungainly in its movements, but it is a great danger to those people in whose lands it is found wild.

It lurks for hours perfectly still in the water or mud by the river bank, and then when the people come to bathe or to get water the crocodile will seize them, drag them beneath the water, and make a meal. This constantly happens, and as proof nothing more is needed than what is found inside a crocodile after it is killed. Beads and earrings and such ornaments worn by women are constantly recovered in this way.

Mr. E. G. Boulenger, a former director of the Aquarium at the London Zoo, tells us in one of his books that inside one crocodile were found eight long rows of beads, which had formed the girdle of a missing native woman; one pair of silver earrings; one single bead of a pattern which had been out of local fashion for a century and a half; one jam jar, and the neck of a bottle. This crocodile was a monster 15 feet long, and was shot in the Gambia River of West Africa.

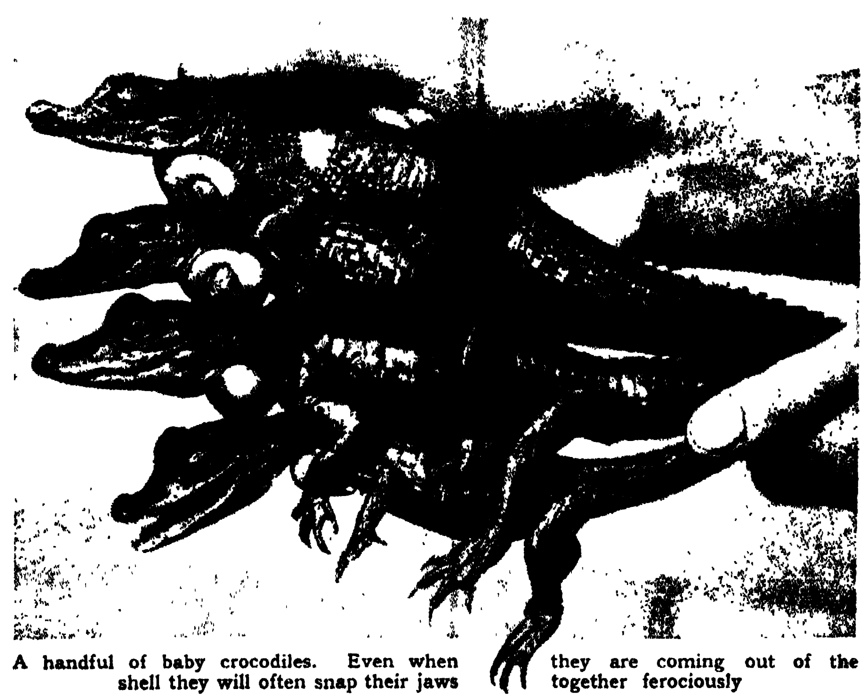
Grim Relics

Another crocodile over 18 feet long, caught in Borneo, when opened up was found to contain the silver ankle and wrist bangles of a Malay woman and part of the clothing of a child; also some Dutch coins often worn by native women as ornaments, and the clothing and pigtail of a Chinaman.

It is difficult to say how long crocodiles live—probably they may even reach 200 years—but Captain C. R. S. Pitman, the game warden of the Uganda Protectorate, says they grow very slowly and that a 2-foot crocodile would be about fifteen years old, while a 3-foot reptile would be about thirty. As they grow older they increase in width more than in length, and Captain Pitman saw a crocodile in Africa, near the Murchison Falls, which measured at least five feet across the back.

They do not crawl with their bodies on the ground, but move with a kind of waddling run with the legs nearly straight and the body raised. The tail, however, drags along the ground and leaves a track as though a plough had passed that way.

Being an amphibian the crocodile attacks on land or water. It will pull a man out of a boat if his arms or legs are hanging over the sides, and it has even been known to put its feet on the side of the boat and grab a man as he was paddling along the river. As a proof of its enormous muscular strength, it may be mentioned that a crocodile has been seen to seize by the hind leg a full-grown rhinoceros as it was leaving the river, and after a tremendous struggle the rhinoceros was dragged under the water and drowned.



A handful of baby crocodiles. Even when they are coming out of the shell they will often snap their jaws together ferociously

Its form is particularly adapted for hunting in the water, for its eyes are raised so that when its whole body is submerged they are just peeping above the water, and when it marks its prey, generally without being seen, it will sink, swim towards it, and seize it without any warning.

When the crocodile pulls a human being or a beast under water its mouth is necessarily open, but water does not pass down its throat, for the tongue is raised and folded so as to meet a transverse fold in the roof of the mouth, and thus closes the opening to the throat. The jaws of the adult crocodile are exceedingly powerful, and can bite a man in two. It can stay under water for quite a long time, and it is both a fast swimmer in the water and a fast runner on land.

A distinguished big game hunter, Mr. J. Morewood Dowsett, says: "The crocodile is the enemy of man—and also of everything that has life—and I do not know that he has one friend, as he is of a surly and bad temper and does not even like his own species. When crocodiles fight together they lie parallel to each other on the ground, the head of one being at the other's tail. They then pound each other's heads with their massive tails."

The teeth of the crocodile interlock when they bring their jaws together, and this gives them a grip that is irresistible.

Crocodiles' Eggs

The crocodile has a habit of swallowing stones which enable it to grind up its food and so help digestion, just as a fowl takes grit to assist the pulverising of the food in its gizzard.

It may seem strange that such a huge and ungainly animal should be hatched from an egg about the size of a large hen's or a goose's egg, yet such is the fact. Of course, every living animal including ourselves has come from an egg, but in the case of ourselves and all the mammals except the platypus and the echidna of which we read in another part of this book, the egg is not laid by the mother in some outside place. But the female crocodile, like the hen, actually lays the eggs—anything up to sixty in number—

in a hollow of the sand by the river bank. The eggs have a white shell just like a hen's and except that they are a little longer might be taken for hen's eggs.

The crocodile does not sit upon the eggs like a bird, but she allows the sun to do the hatching. Some crocodiles, like those of the Dutch Indies, actually build a nest of leaves, twigs and branches, and there lay the clutch of eggs. The mother then retires to a distance, where she watches the eggs so that marauding monkeys may not come and steal them. Some several weeks later the young reptiles hatch out.

When the young crocodile is ready to emerge, it makes some kind of sound which attracts the mother, and if the eggs are buried in the sand the mother crocodile at once uncovers them. The baby inside then cracks the shell and pokes the tip of its nose out. Then it pushes the whole of its head out and gradually more and more of the body emerges, till at last it has freed itself completely from the shell. It shows its character even before it is actually hatched, for it will snap if touched immediately its head has been pushed outside the shell.

As soon as the young crocodiles are hatched, they are quite well able to look after themselves and make their way at once to the water, where they begin preying upon living creatures suited to their size.

The young crocodile makes its way out of the shell by perforating the hard substance at one end by the aid of a tooth which is specially developed in the early stages for this purpose. It may take the crocodile a couple of hours to get free of the shell from the moment when it first attacks the inside.

The crocodiles bear the nearest resemblance among living creatures to those monster reptiles that lived in prehistoric times; in fact, their whole form has a very prehistoric appearance. They are of no commercial value, their skins being far too horny to be tanned into useful leather. The so-called crocodile hide, which is used for making bags and other articles, is really the skin of the American alligator.

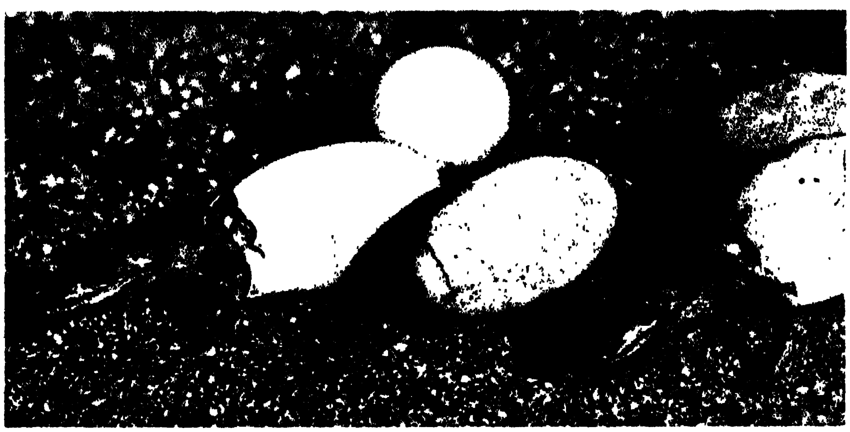
Two baby crocodiles caught in the act of emerging from their shells

Some African natives eat the flesh of the crocodile and also its eggs, but the number who thus make use of it is not great, for its body is supposed to be the abode of evil spirits.

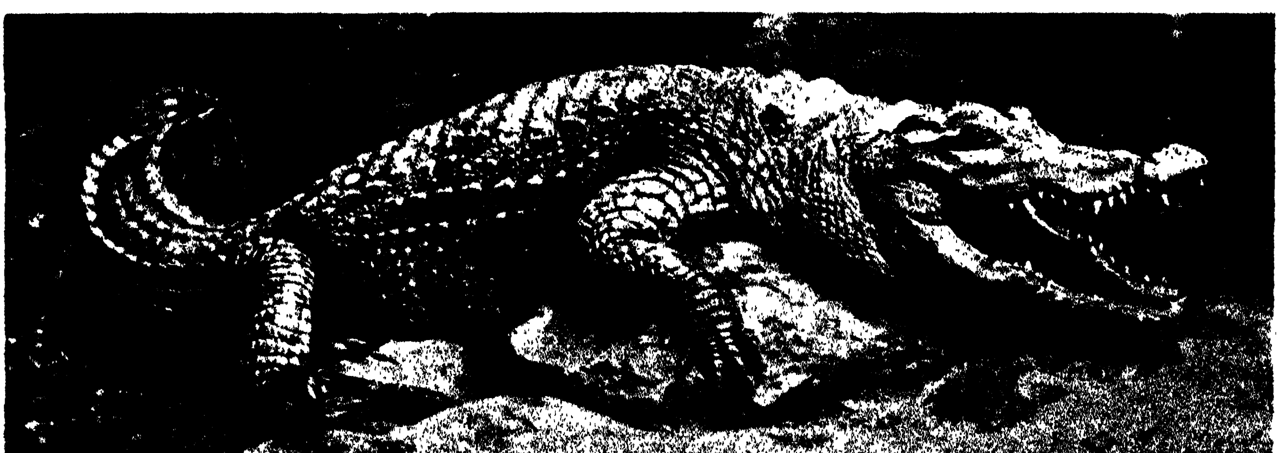
The greatest enemy the crocodile has is the ichneumon, a little animal of the size of the ferret, which eats its eggs

We often hear the expression "crocodile's tears." Mr. Morewood Dowsett tells us that the expression originated through the peculiar provision of a third eyelid in addition to the upper and lower lids. "It is transparent blind or screen," he says, "which is composed of an extremely thin membrane, is drawn across the eyeball of the crocodile and a special gland supplies a fluid which makes the eye wet."

Few people seized by a crocodile ever manage to escape, but Mungo Park, the traveller, tells how his native attendant Isaaco had a wonderful escape. He was attempting to drive six asses across a river when a crocodile rose and seized him by the left thigh It pulled him under water, but with wonderful presence of mind he thrust his finger into the crocodile's eye, and this forced it to quit its hold. It returned to the charge, however, and seized the unfortunate man by the other, thigh, again pulling him under water. This time Isaaco thrust his fingers into both eyes with such force that it left him and swam away.



A clutch of crocodile eggs. Two are seen with the young hatching out and another is cracked ready for the escape of the crocodile



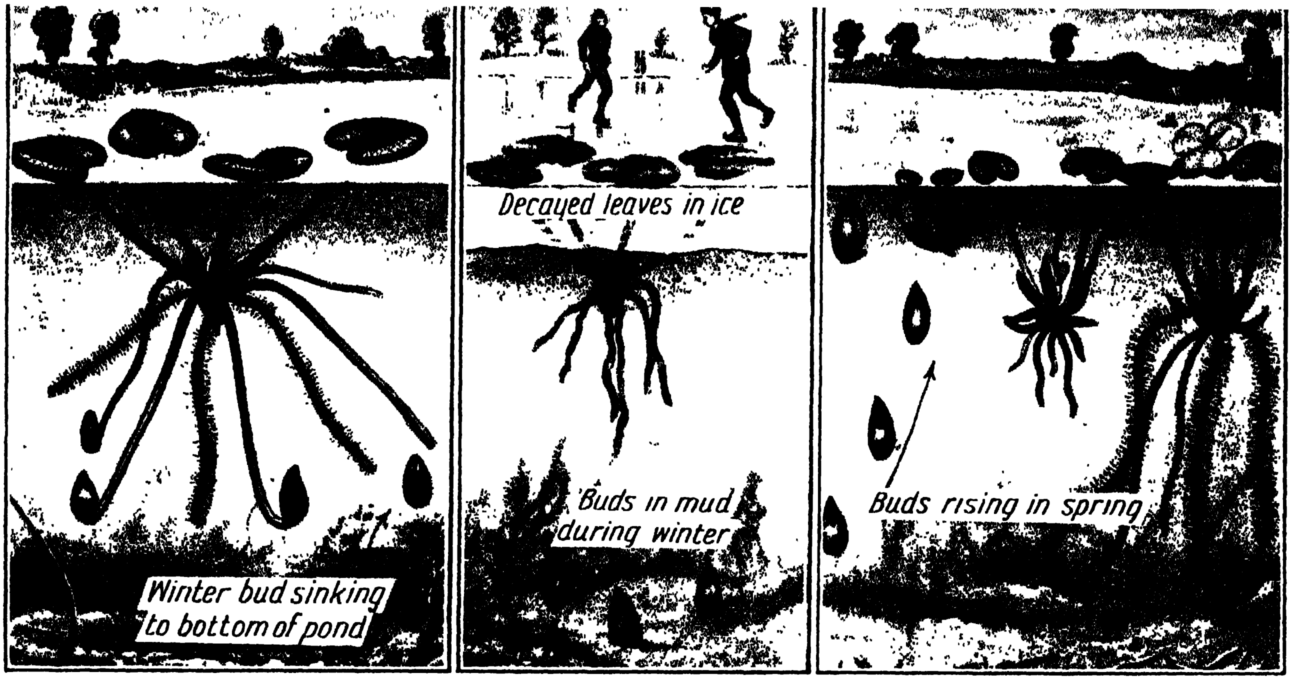
A villainous-looking crocodile in an angry mood. With one snap of its jaws it could bite a man in two

GIANTS OF THE ANIMAL WORLD AT REST

In a land like England where the elephant is not found outside zoological gardens and circuses, we rarely see it in anything but an upright position. It generally sleeps standing up. Yet the elephant likes to lie down sometimes, and here we see how curious it looks when resting on the ground. Although the elephant looks clumsy because of its size, it is not really clumsy in its movements

Another giant animal which is not often seen lying down is the hippopotamus. This photograph, which was taken at Whipsnade shows a hippopotamus which had been removed from the London Zoo lying down in a pool of rain water that had formed on the ground after a heavy storm. In its natural home the animal, of course, spends the greater part of its time in the water of a river

HOW THE FROGBIT SURVIVES THE COLD



The frogbit, one of our native British water plants, has a curious method of surviving the cold weather of winter. This plant does not root itself in the earth but floats with its flat leaves lying on the surface of the water. When the flowering season is over it sends out runners under the water and on the end of each a winter bud forms as shown in the first picture. These buds are full of starch and other plant foods, and when the water begins to get cold, they detach themselves from the runners and fall to the warm mud below, as in the second picture. Here they live through the winter though the pond may be frozen over. Then when spring comes the buds undergo changes which make them lighter, they rise to the surface as in the third picture, and soon develop into new plants

A FISH THAT LOOKS CAREFULLY AFTER ITS YOUNG

We do not usually think of fishes as being devoted parents, but there are some that look after their young with as much care as a hen looks after her chickens. The common stickleback is one of these. The father fish guards his growing young, and by gently moving his fins to and fro fans towards the nest in which they are living a continuous stream of fresh water, so that his offspring may have an adequate supply of oxygen. If anything threatens his family the father stickleback erects his spines and makes a fierce attack on the foe.

Another fish, the male of which is a devoted parent, is known as the geophagus. After the young fish are hatched out the father follows the little family about as they swim hither and thither in the same way as a hen follows her chickens. Should one of the youngsters venture too far away from the family, the parent at once darts after it, seizes it with his mouth and flings it back among the rest.

It is perhaps remarkable that among fishes, as well as among certain of the amphibians, it is the male in most cases that cares for the offspring. The mother, whom we should expect to show the greater solicitude, appears to take no interest of any kind.

The male geophagus, a Brazilian fish, going for a trip in the water with his family

MANY KINDS OF MACHINERY IN THE HOME

Although we do not often think of it that way, machinery is used in the home as well as in the factory, and on this page we read of some of the more familiar kinds of domestic machinery, both simple and complex. No home, in fact, to-day is without machinery of some kind

To the average housewife machinery does not seem a very interesting subject. In the old days no girls or women at all had any interest whatever in machinery; but nowadays, when there are so many motor-cars driven by women, many girls take as intelligent an interest in machinery as men.

When machinery is spoken of people usually think of factories or railways or ships or motor-cars or aeroplanes, but there is a good deal of machinery in every home. This is obvious when we remember that the lever and the wedge and the screw and the pulley are all simple machines. No home could get on without these. The knife used for cutting is a double wedge, the pulley is used to pull up the clothes line, and every time the housewife or maid stirs the fire she uses the poker as a lever.

But it is not only in this simple form that machinery is used in the home. There are all sorts of machines in which the various mechanical principles are used in a more or less complicated way. Perhaps one of the best known is the mangle or wringer, where we get the wheel and axle in play, the transmission of power by means of toothed wheels, and the changing of speed by gearing.

Then there is the sewing-machine, the working of which has already been explained on page 766. This is really a very clever and ingenious machine, and is quite worthy to be compared with the more elaborate machines that are used in factories.

A machine of a smaller kind, but which is also very ingenious and a great saver of labour, is the egg-beater, in which not only great speed is obtained by means of gearing, but by means of bevelled-toothed wheels there is a change of direction, so that while the handle is turned in a vertical plane the blades that beat up the egg are turned in a horizontal plane.

A machine of a different type is the vacuum-cleaner, another ingenious adaptation of a scientific principle to labour-saving in the home. Here by means of bellows or fan a vacuum is created and the dust and litter are drawn up into the apparatus, or to put it more scientifically, they are driven up by the pressure of the air which rushes in to fill up the vacuum.

Then there are the scales which are used for weighing the goods. These form a machine in the true sense of the word, whether the ordinary scales with two pans are used, or whether the form be that of the spring balance.

Even in the old days machines were used in the home. The cooking jack which was wound up like a clock and turned the meat first in one direction for several minutes and then reversed and turned it in the other direction, was a very ingenious machine. It is sometimes used now, though not very often.

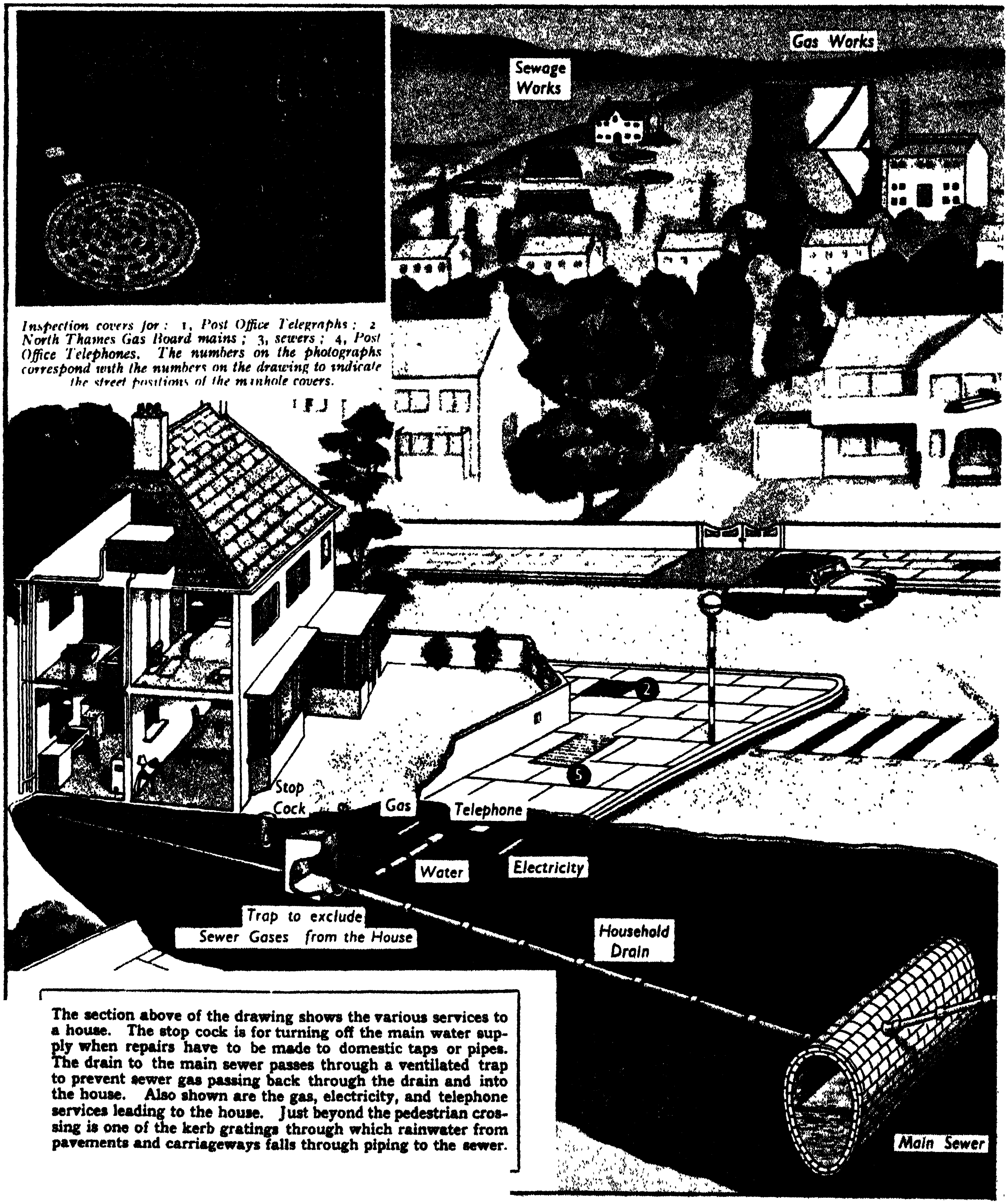
It will be interesting to go through our home and make a list of machines both simple and complex that are to be found there. Among the simple machines we shall find levers and wedges in such things as knives and scissors and shears and pincers and nails. We shall find the inclined plane in screws of various kinds, and then we shall find more complicated machines like those that have been named, the locks on the doors and cupboards and drawers, the cisterns and taps, and so on. The list when complete will certainly surprise us.

Most of the machines in the home are of course worked by hand power, but in the vacuum cleaner we have electric power in use.

Even in the old days the idea of using some power beside ordinary hand power was put into practice, as in the spit, on which the birds and meat were turned for roasting before the fire. The spit was in many cases worked by means of a little dog that kept running in a wheel, and instead of making progress rotated the wheel. This was connected by a band with the spit, which it kept turning continuously

Here are two examples of machinery in the home On the left is an egg-beater with gear wheels which change slow motion into rapid, and also change its direction. On the right is an electric vacuum-cleaner. The current from a plug in the wall rotates a fan and a rod with brushes. The brushes stir up the dust and the suction caused by the fan draws the dust up into a bag

CAN YOU RECOGNIZE THE MANHOLES YOU

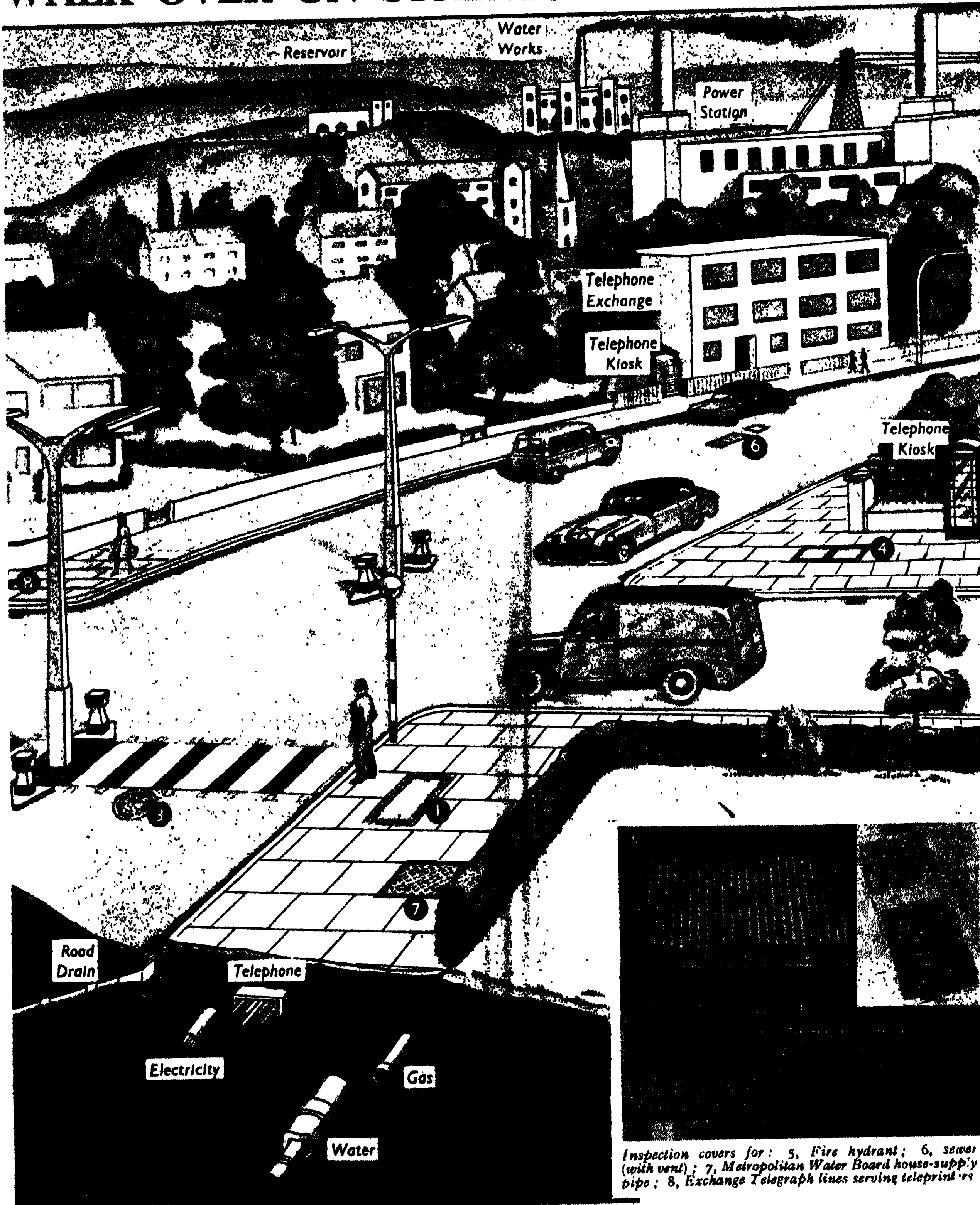


Inspection covers for: 1, Post Office Telegraphs; 2 North Thames Gas Board mains; 3, sewers; 4, Post Office Telephones. The numbers on the photographs correspond with the numbers on the drawing to indicate the street positions of the manhole covers.

The section above of the drawing shows the various services to a house. The stop cock is for turning off the main water supply when repairs have to be made to domestic taps or pipes. The drain to the main sewer passes through a ventilated trap to prevent sewer gas passing back through the drain and into the house. Also shown are the gas, electricity, and telephone services leading to the house. Just beyond the pedestrian crossing is one of the kerb gratings through which rainwater from pavements and carriageways falls through piping to the sewer.

Few of us walking along a busy street realise the complicated network of pipes and cables below our feet. Every drop of water, every unit of electricity, every cubic foot of gas, every telephone call, makes some part of its journey underground. Similarly, sewage and domestic waste leaving our houses travel underground on their way for disposal. The only indication of what goes on under the street is provided by the metal plates, called manhole covers, let into the roadway and pavement. To most people one manhole cover is very much like another, but as the drawing and photographs on this page show, each kind of service has its own distinctive type of cover. Without these underground services, life as we know it today in towns and their suburbs would be impossible. Indeed, a street of houses can be likened to a human body, and the network of pipes and cables can be compared with the veins and arteries that supply it with life. Consider, for example, water supply. From some such source as a river, the water is conveyed through pipes to a reservoir, usually on high ground, as in the drawing, where it is filtered through successive

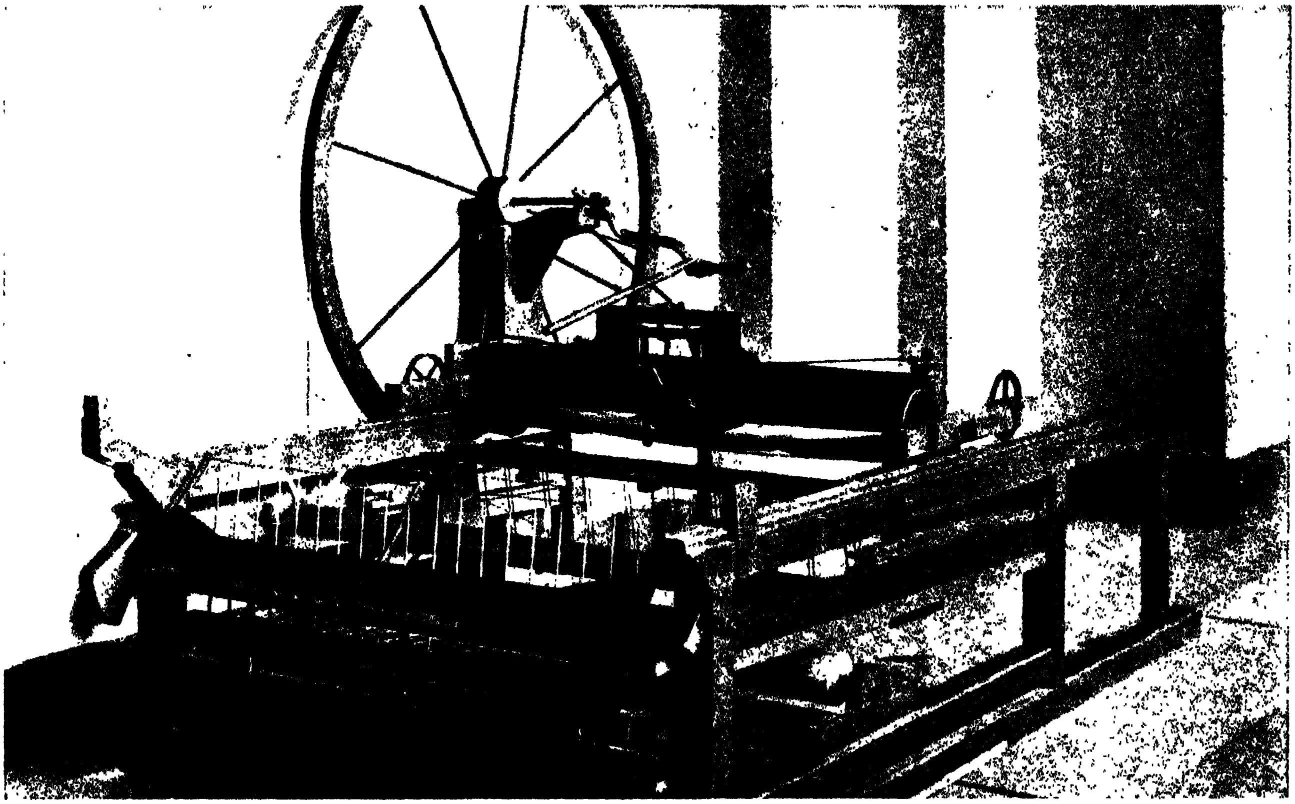
WALK OVER ON STREETS AND PAVEMENTS?



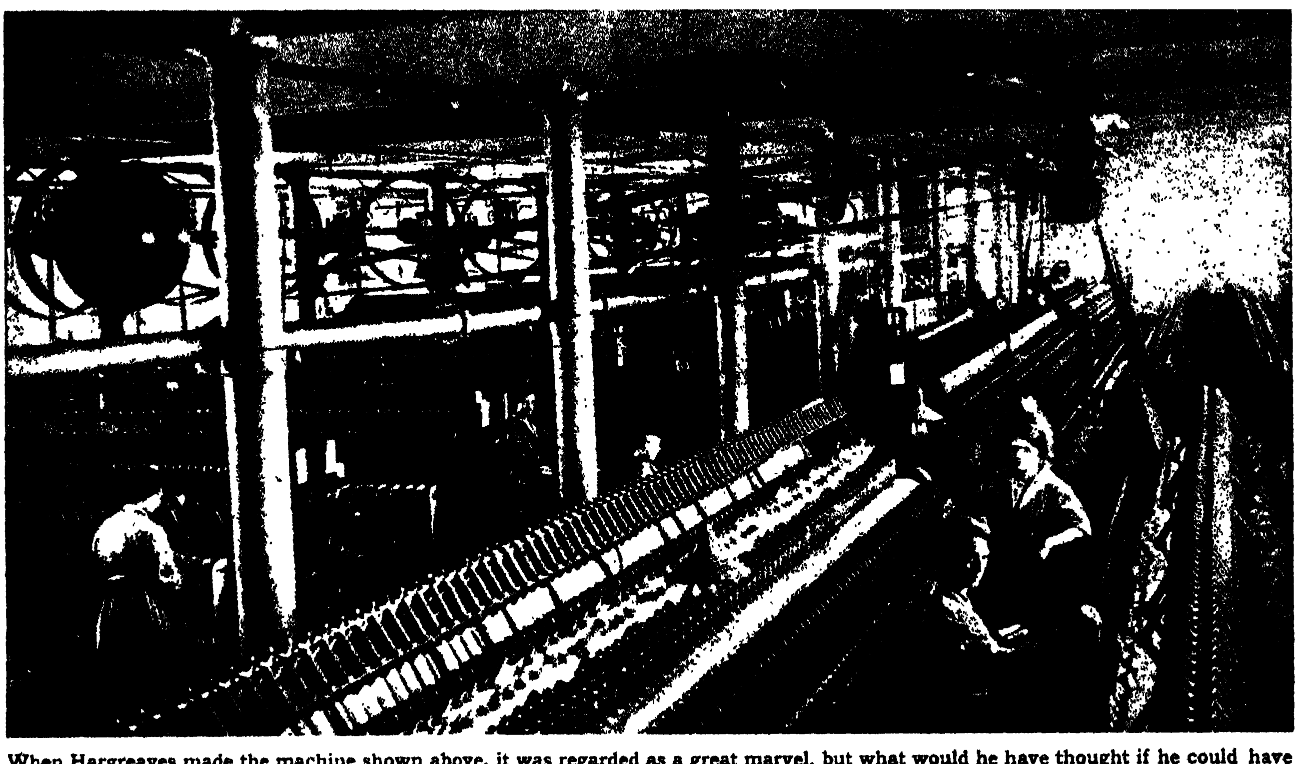
Inspection covers for: 5, Fire hydrant; 6, sewer (with vent); 7, Metropolitan Water Board house-supply pipe; 8, Exchange Telegraph lines serving teleprinters

layers of gravel, sand, and chalk. The water then flows, often by gravity, to the waterworks, whence it is pumped through the mains to the various streets. From the street mains smaller pipes lead to the houses and other buildings. There the supply is carried to tanks in the roofs, from where it flows to the bathrooms, lavatories, kitchens, and other rooms using water. From the street mains branch other pipes leading to the fire hydrants and to the stand-pipes used for flushing the streets and the rainwater gullies. In the reverse direction we have the underground sewage service. From sinks and other sources liquid waste flows through drain-pipes to the main sewer, through which it is pumped and carried to the sewage works. At some sewage works the affluent, as the waste is called, is treated with chemicals which dissolve the solids and render the liquid harmless. In the drawing the artist has for convenience shown the sewage works on high ground close to the waterworks, but in practice the sewage would be treated on low ground to prevent the water from being contaminated. The drawing also shows gas, electricity, and telephone services.

THE OLD AND THE NEW SPINNING MACHINES



For centuries the spinning of thread was done by hand, a spinning wheel being used to help in the twisting of the fibre. Then, in the second half of the eighteenth century a number of men invented machinery to spin the thread more quickly. It was James Hargreaves, however, who in 1770 patented the first really serviceable spinning machine and here we see what his machine was like. This replica of Hargreaves' spinning jenny is given by courtesy of the Director of the Science Museum, Kensington



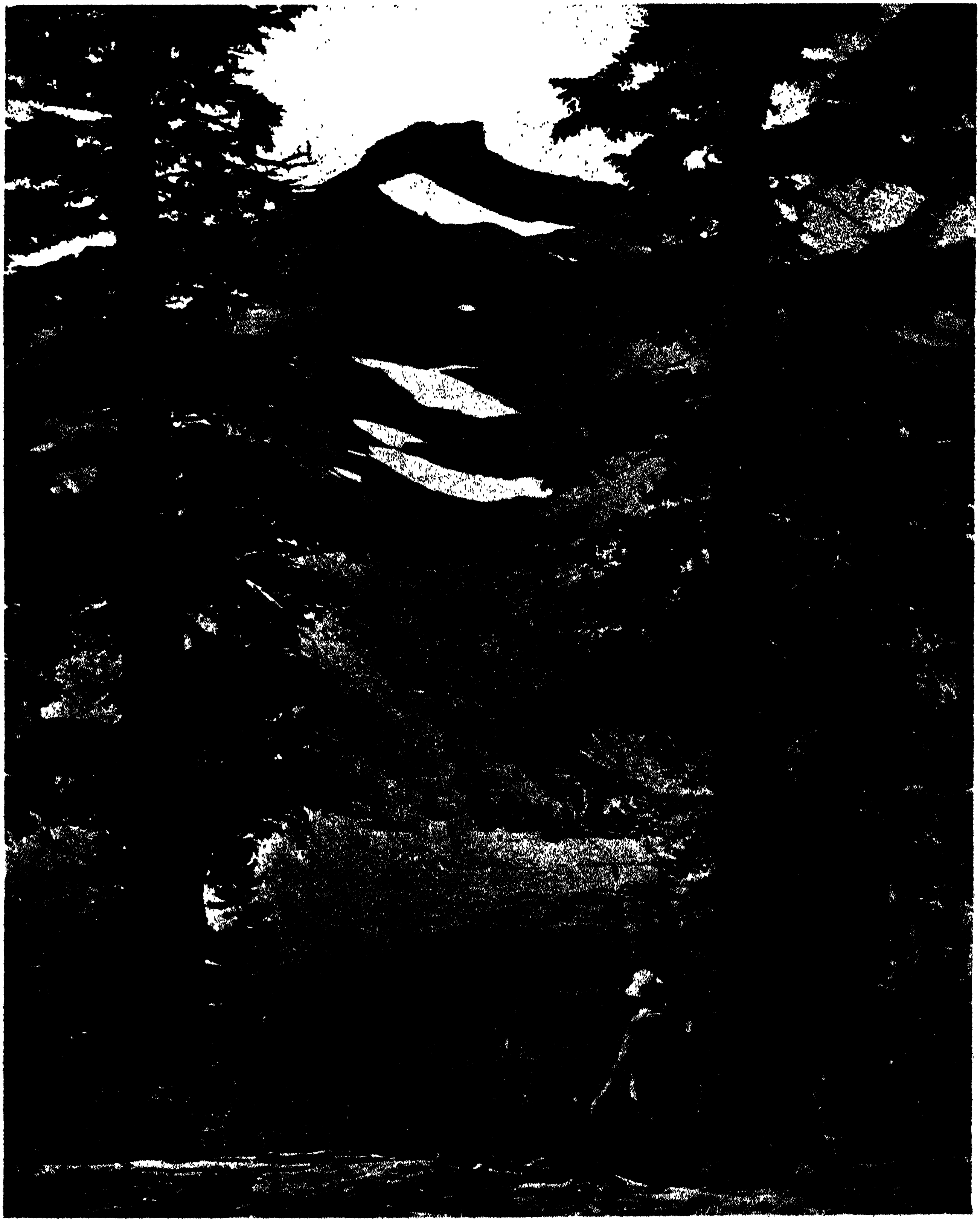
When Hargreaves made the machine shown above, it was regarded as a great marvel, but what would he have thought if he could have seen a modern spinning machine as shown in this photograph? It is as far in advance of the old machinery as that was in advance of the hand-wheel. A modern spinning machine is a mass of whirring spindles that turn at the rate of over eleven thousand revolutions a minute, but yet is based on the inventions of Hargreaves, Arkwright and Crompton of whom we read on pages 1061 to 1065

GIANT ENGINES OF TWO RAILWAYS

The photographs on this page give an interesting comparison of two fine specimens of British and Canadian locomotives. The smaller of the engines is the "Royal Scot" of the former London Midland and Scottish Railway. With its tender it weighs over 127 tons. It is known as a 4—6—0, and its coupled wheels are 6 feet 9 inches in diameter. The total length of engine and tender including the buffers is more than 63 feet. The boiler pressure is 250 pounds to the square inch and it carries 3,500 gallons of water and 5½ tons of coal.

We see in the upper photograph a front view of the Royal Scot beside one of the largest Canadian Pacific express engines, and here we see a side view of the two engines. The photographs were taken when the Royal Scot was making a tour of Canada and the United States in 1933. Canadian and American engines are much larger and heavier than British locomotives, but no engines in the world are so well finished as are British locomotives. In the United States the locomotives in some cases weigh, with their tenders, 350 tons.

A GREAT RANGE OF EXTINCT VOLCANOES



Here is a view in Oregon of the Cascade Mountains, a great range of extinct volcanoes that runs for about 500 miles across the States of Oregon and Washington into British Columbia. Some of the loftiest peaks are over 14,000 feet high, and there are evidences throughout the range that here, in comparatively recent geological times, was a long line of active volcanoes. All the chief heights are old volcanic cones and many are covered with snow, while on others the snow which falls in winter mostly melts in summer, though in depressions where it has settled in deep drifts it lies well into the summer months in large patches, as seen in the photograph

THE WORK THE GLACIERS DO

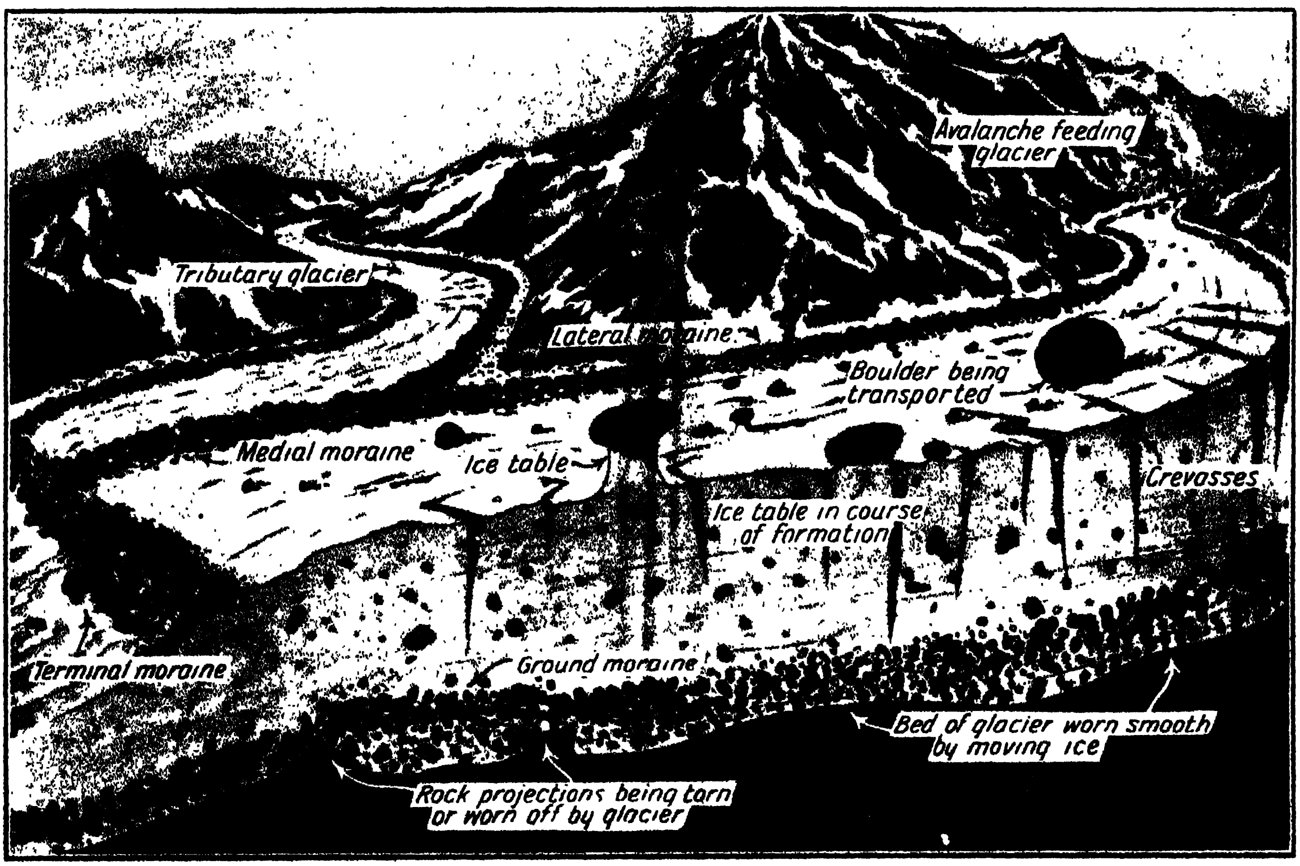
Glaciers are great sculptors of the lan ls over which they flow. While rain and wind tend to make land surfaces irregular and angular, the glaciers round off the irregularities and wear the surfaces smooth. We find this going on to-day in mountainous regions, and we find the results in lands like Great Britain where there used to be many glaciers but where they exist no longer. Here we read something about glaciers as eroding agents

THOSE rivers of ice known as glaciers, which carry away the snow fallen on the mountain tops or in the frozen regions of the north and south, do an important work just as liquid rivers do. In the first place they level the ground over which they flow and in the second place they transport material as they go along. A glacier is indeed something like a continuous band-conveyor used in factories for carrying articles from one part of the building to another.

The rocky bed down which the glacier flows so slowly was, at one time, rugged like the rest of the mountain, but as the hard ice has passed over the rough surface it has either broken off projecting points of bedrock or, if they were too strong to be broken off, it has gradually worn them down till the bed in which the glacier flows is very smooth. The rock at the sides of the glacier, too, is worn smooth by the travelling ice.

It is, of course, not easy to see the bed of an existing glacier, but we know what happens by examining the dry bed over which a glacier flowed in bygone geological ages. The rock is worn smooth, and every here and there we see scratches made by broken off rocks that were carried along at the bottom of the glacier and scraped the bed as they travelled. We know this was the cause of the scratches, for they run all in one general direction. Sometimes, of course, it is possible to creep in under the ice at the end of a glacier and examine its bed, and here the same thing is found as in the bed of a prehistoric glacier.

It is not merely the ice that wears away the rocky bed. Rocky fragments that fall upon the glacier and tumble down crevasses often become frozen into the ice and they, too, are dragged along over the rock assisting in wearing it away, till it becomes quite smooth. In course of time this wearing deepens the valley or channel down which the glacier flows. The wearing is not uniform throughout the course of the glacier, for at places the ice flows more rapidly than at others, and in narrow channels the weight and pressure may be greater owing to the



In this picture-diagram, which shows a section through an Alpine glacier, we see how masses of rock, including large boulders and small stones, are carried down by the ice. Some of these materials are transported on the surface, some embedded in the ice, and some pushed along on the bed of the glacier, wearing the rock smooth as it goes. In some cases large rocks protect the ice underneath from the sun's rays, which melt the ice all round till what is known as an ice-table is formed. The amount of rock, stones and ground-up fragments carried by a glacier is enormous. One Alpine glacier at its outlet deposits 1,968 tons a day, and a glacier in Iceland is estimated to deposit every year 14,763,000 tons of solid matter

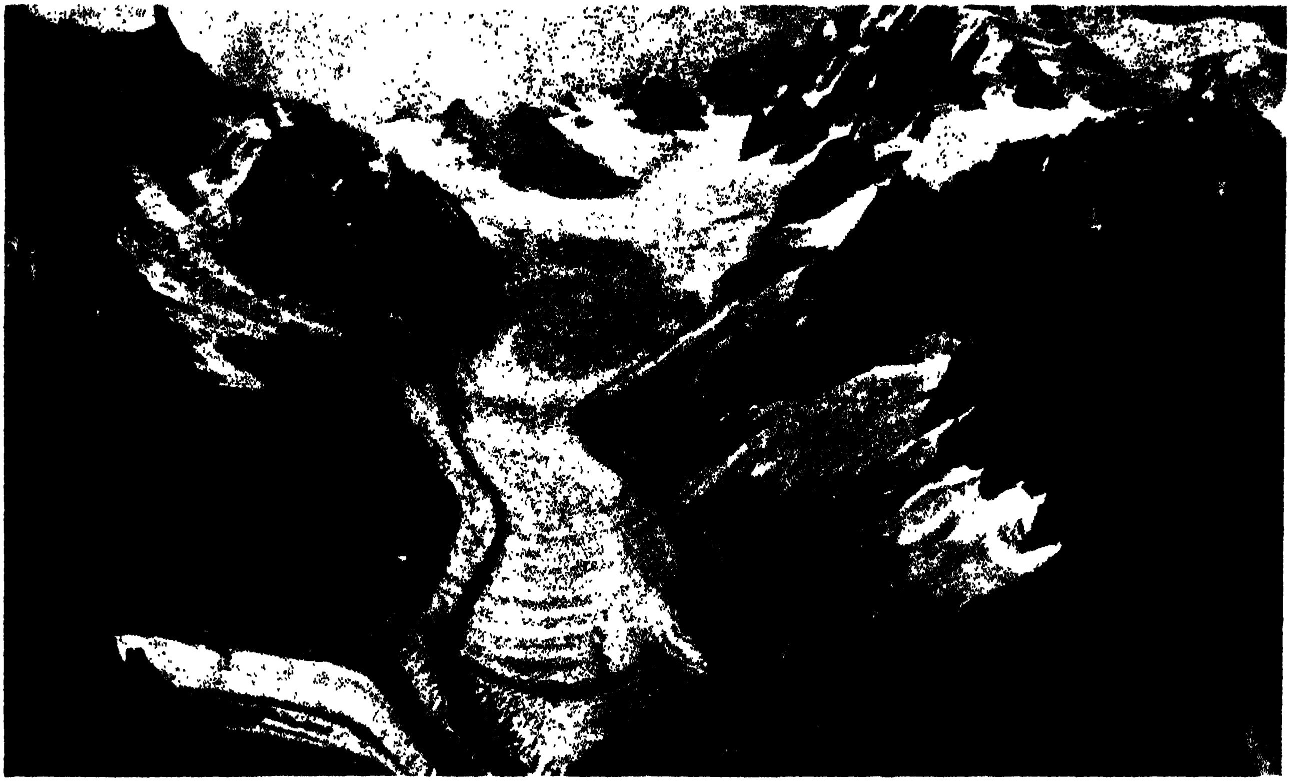
concentration of the glacier into smaller space.

If we stand at the end of a glacier we shall notice that the water which comes from it is dark and muddy. Where does the mud come from, that is the earthy material which makes the water dirty? We know the ice is clear, and if it was merely melted ice that poured away at the end of the glacier the water would be quite clear also. The solid matter in the water that makes it muddy is really the ground-up rock from the glacier's bed, and so glacier melts and, of course, as the ice becomes water the rocks and stones and boulders lying upon it sink down and form a heap which is known to scientists as a terminal moraine. In this way thousands of tons of rocks are carried many miles.

In days gone by glaciers used to flow in England, and we can find the places by looking out for these terminal moraines as well as for the scratched or striated rocks.

Glaciers to-day are among the powerful sculptors of the Earth's face. another so that one or more faces are scratched. This explains why we sometimes find a group of boulders and smaller stones in England with the scratches due to glacier action in distant ages.

It might be thought that the greater part of the material carried by a glacier consists of the moraines on its surface, but as a matter of fact more material is carried in the lower part than above. This is called a ground moraine. There is the matter from the bed itself and the large quantity of matter that falls



A great glacier on Mount Grépon, Switzerland, with its moraines or lines of rocky fragments fallen from the peaks above, and another glacier joining it from another valley. As can be seen, two lateral moraines have joined and formed a medial moraine

in this way the glacier not only acts as a levelling agent, but it transports solid matter as it travels. The matter carried, however, is not merely the solid matter worn off the glacier's bed, but large quantities of rocks, together with boulders that fall upon it from the mountains.

We have already seen on pages 382 to 385 that this matter which falls along the sides of the glacier forms two lines of large or small fragments which are known as lateral moraines. Slowly but surely these are carried down the mountain and then, when the glacier meets another glacier where two valleys join, they become one and the inside lateral moraines form a large central moraine known as a medial moraine. Perhaps lower down still a third joins up and then there may be two medial moraines.

Sooner or later, however, the transported rocks reach the place where the While a glacier does not travel with the rushing force of a river, it is powerful because the ice freezes to the soil over which it passes and anything that is at all loose must travel with the ice because it is gripped so tightly. All loose débris, therefore, falling through the crevasses or broken off from the rocky bed, must inevitably go down with the glacier. Sometimes, if part of the bed of the glacier is made of softer rock than other parts, there will be not merely scratches made by the transported stones at the bottom of the ice, but great grooves. These are made by the larger boulders and rocks that fall through the crevasses or are broken off the bed.

The finer matter at the bottom of the ice simply polishes the rock. Not only is the bed of the glacier striated or scratched, but the transported rocks themselves, as the glacier changes direction, are rubbed against one down through the crevasses. The mountains above the glacier are constantly being weathered, so that fragments are falling all the time and, of course, there are avalanches that bring large quantities down together.

The material that is left by the glacier after it melts is called by scientists glacial drift. The lateral moraines which are left when a valley glacier has disappeared altogether are often of huge size, sometimes hundreds of feet high and occasionally a thousand feet or more. In the north of Italy there is a lateral moraine which is about 2,000 feet high. It was made by a giant glacier that used to move down from the Alps in a past age when the climate of Southern Europe was much colder than it is to-day. When a glacier in its course receives many side branches its whole surface may be practically covered with debris from one side to the other.

IF THE GULF STREAM CHANGED ITS COURSE

The genial climate which the British Isles enjoy without those extremes of heat and cold that are found in North America, is due to the current of warm water that encircles these islands. A warm current from the equator sweeps round the Caribbean Sea and emerges as the Gulf Stream, as shown in the picture map on page 50. After the force of the Gulf Stream is reduced it passes as a warm drift across the Atlantic and saves us from those intensely cold winters that are experienced in similar latitudes, where its genial warmth is not experienced. Scenes like that shown in this photograph, taken at Stow-on-the-Wold in the Cotswold Hills, are therefore rare in England

Snow in London is a rare occurrence, thanks to the Gulf Stream drift. But if by any chance the Gulf Stream were to change its direction then we should find that London would be more like Leningrad or Toronto in winter, and Trafalgar Square and other main thoroughfares would look like this very often, instead of presenting such a scene only at rare intervals. The current acts as a warm scarf

HOW THE CLIFFS OF DOVER WERE FORMED

Millions of years ago that part of England where we now see the South Downs and the cliffs of Dover was under water. The sea had dissolved in it many minerals, and there were living in it myriads of tiny creatures that were like little specks of jelly. These creatures lived near the surface where the water was warm, and they had the power of extracting calcium carbonate from the water and making from it tiny shells to live in. Then, when they died, the shells would sink through the water and lie on the bed of the sea

The little creatures have been given the name of foraminifera, from two Latin words which mean "I bear" and "an opening." This is because their tiny shells contain many holes. The shells of the foraminifera are so small that it would take a million to form one cubic inch, and we can see what they are like only by looking at them through a microscope. There were so many billions of them constantly falling on the sea-bed that in the course of centuries there was quite a thick layer. Other creatures like sea-urchins also died and fell to the bottom among the foraminifera. At the bottom of this picture we see foraminifera shells highly magnified

Layer after layer was deposited, and the weight became so enormous that the vast collections of tiny shells were squeezed into hard masses. Then as the Earth cooled and its crust wrinkled the sea-bed was raised above the surface of the sea, and formed what we now call chalk. The cliffs of Dover are part of the old sea-bed, and if we look at a piece through a microscope we can see the minute shells of what were once living creatures. Similar creatures now live near the surface of the Atlantic Ocean and as they die and fall to the bottom their remains form similar layers which may one day be raised up and form the chalk hills and cliffs of the future world

THE MARVELLOUS PUMP IN YOUR BODY

If our blood did not circulate in our bodies we could not live, and it is the heart that acts as a pump and drives the blood to every part of the body. It is the most wonderful pump in the world, for it drives the blood at such a rate that it travels through arteries, capillaries and veins back to the heart again in 22½ seconds. Here are some interesting facts about the heart and its great work

We all know the wonderful system by which the water is laid on to our houses. The water supply is produced by the action of the Sun and the wind, but it would be of little use if there were not some efficient method of circulating it to the places where it is wanted.

In order that this can be done there must be a central pumping station with powerful pumps driving the water through large water mains, and from them into lesser mains and finally through narrow pipes to the taps in our sculleries and bathrooms. If any thing goes wrong with the pumps the circulation of the water is interfered with, the supply is cut off, and we know that without water it is impossible for us to live.

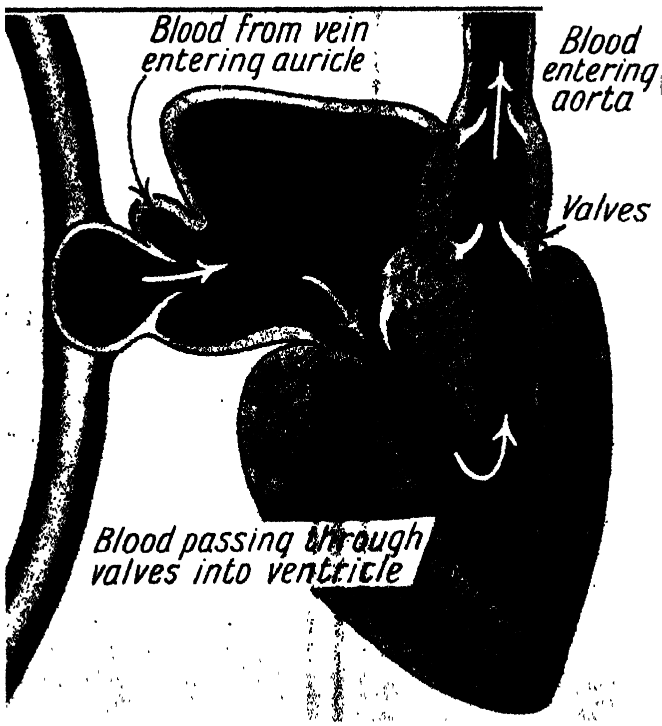
The Pump and the Pipes

Now just as the life-giving water supply of a town or city is driven through an intricate maze of pipes by means of a central pumping station, so in our bodies the life-giving stream of blood is circulated to all parts through a maze of pipes varying in diameter, by a central pump of great power. This pump is called the heart, and the pipes through which the blood is driven are known as arteries, veins and capillaries.

It is a marvellous system The heart is the most efficient pump for its size that has ever been known, and it goes on working day and night, week after week, and year after year, all our lives. Unless accident or disease causes trouble, the pump never fails. And yet how rarely we ever think of the wonderful pumping and circulating system which we carry about with us inside our bodies.

We have already learnt on pages 121 to 123 something about the important work which the blood does in carrying food and oxygen to all parts of our body and keeping the temperature of the body even, but it was not till the early part of the seventeenth century that the great discovery was made of the circulation of the blood through the body The man to whom the world is indebted for this great discovery was a famous English doctor named William Harvey, who was born at Folkestone, and educated at Cambridge University. By his discovery he laid the foundation of the modern science of physiology.

It is difficult for us to-day to realise how mysterious the action of the blood seemed to the early anatomists, before they knew the fact of its circulation. Harvey made many experiments with snakes, frogs, fishes, and



The heart is a pump, and in this very simplified diagram we see how the blood passes from the veins into the chamber known as the auricle and thence through valves into the chamber known as the ventricle, from which through further valves it passes into the aorta, or great artery, and to the smaller arteries. Actually in its passage it is purified in the lungs, as shown in the picture on page 1052

other animals, before he arrived at the great truth, and even he could not discover how the blood, after going through the arteries, reached the various tissues of the body and eventually returned through the veins. That discovery was made about half a century later, by an Italian anatomist named Marcello Malpighi, but it was Harvey who took the first step

Before considering the wonderful system of pipes laid in all parts of the body, let us learn something about the pump that drives the blood. The heart is a reddish organ in the form of a blunt, hollow cone, about the size of its owner's closed fist, and in a grown-up person it weighs only about nine ounces The upper part of the heart, where the great blood-vessels join it, is broad and although it is at the top it is called the base of the heart. The lower end or apex lies a little towards the left side of the body.

Most people think of their heart as a solid lump of flesh, but it is not like that at all It is hollow, and there are four chambers, the heart being divided down its length into two halves, right and left, each of these halves being again divided transversely into two, making four chambers in all

A Triple Covering

There are three coats to the heart. The first is an outer fibrous coat which doctors call the pericardium, a word from the Greek which simply means "round the heart." This consists of two layers, the inner layer being in contact with the heart itself and the outer layer being connected to the tissue all round.

The middle coat of the heart, which in a strong man varies from a quarter of an inch to an inch in thickness, is made up of muscles and forms the chief substance of the heart itself The inner coat is a thin pliable lining.

It is the muscles of the middle lining controlled by certain nerves from the brain that form the pumping apparatus of the heart. Indeed, the heart is really a hollow muscle containing four chambers. These four cavities have special names. The upper chambers are known as the right and left auricles, so called because they are supposed to resemble in shape the auricle or external ear. The lower chambers are known as the right and left ventricles, so called because they are in shape like the ventricle or

abdomen, the cavity of the body which contains the stomach and other organs.

From the left ventricle there leads out a great pipe or artery called the aorta. The name comes from a Greek word meaning " to lift or heave," and it is given because the blood is lifted through this pipe.

The great pipe or aorta is like the big water main leading from the water works of a town, and branching from it are a number of smaller pipes leading to the head, arms, legs, and different organs of the body. Each of these smaller pipes or branch arteries has still smaller branches, and at last these lead into very tiny pipes or blood vessels called capillaries, which are laid in the tissue of practically every part of the body, just as the small lead water pipes are carried into the different parts of all our houses.

These capillaries are so small that they cannot be seen except through a microscope and it would take from 1,500 to 3,000 laid side by side to make an inch. Some, of course, are smaller than others. Yet although they are so tiny the capillaries altogether hold 500 times as much blood as the whole of the arteries in our bodies.

The Blood's Double Journey

The only parts of the body from which they are absent are the outer skin, certain layers of the inside membranes, the nails and hair, the substance of which our teeth are made, and the transparent coat of the eye known as the cornea.

The blood passes from the heart through the aorta and arteries to the capillaries, and then from those little tubes it passes into larger and larger pipes similar to the arteries, but known as veins, and eventually reaches a very large tube or vein known as the vena cava, or cave-like vein, returning thence into the right auricle.

This gives a rough idea of how the blood circulates through our body, but it is not the whole story. When the blood is pumped out through the aorta into the arteries, the red corpuscles are loaded with oxygen and when the blood comes back through the vena cava it has little or no oxygen and is loaded with impurities which it has collected on its journey. Before it sets out again on its voyage through the body the red corpuscles must be loaded up with oxygen, and this is done in the lungs.

Now let us follow the course of a particular portion of the blood. The right auricle receives the blood that has come back through the capillaries from all parts of the body except the lungs. The impurities which it has collected must be removed and it must be given a supply of oxygen. How is this done? Well, it flows from the right auricle through little trap-doors into the right ventricle.

The trap-doors or valves open only one way, so that the blood cannot return from the right ventricle into the right auricle. As soon as the ventricle is full of blood its muscular sides squeeze together and the blood is pumped or pressed through another set of valves into an artery leading to the lungs. This artery is known as the pulmonary or lung artery.

In the lungs, which are like bags filled with spongy material, so that air can get from the windpipe to every corner, the blood is brought very close to the air-sacs, and while the red corpuscles collect oxygen from the air in the sacs the blood also gives up the impurities it has collected on its return to the heart. It is because of this that the lungs have been described as a kind of port which imports pure oxygen and exports useless substances.

The blood pumped into the lungs was dark in colour, because of its impurities, but now that these have been removed and a fresh supply of oxygen has been taken in, the blood is once more bright red and is ready to start off on its journey through the body.

From the lungs it passes through a large vein called the pulmonary or lung vein into the left auricle and then through valves into the left ventricle. Once more the muscular walls or pump contract and the blood is forced or pumped into the aorta or largest artery in the body. The constant pumping of the left ventricle drives the blood from the aorta into the various arteries and into the capillaries, till it returns through the veins to the vena cava, and the whole process is repeated again and again.

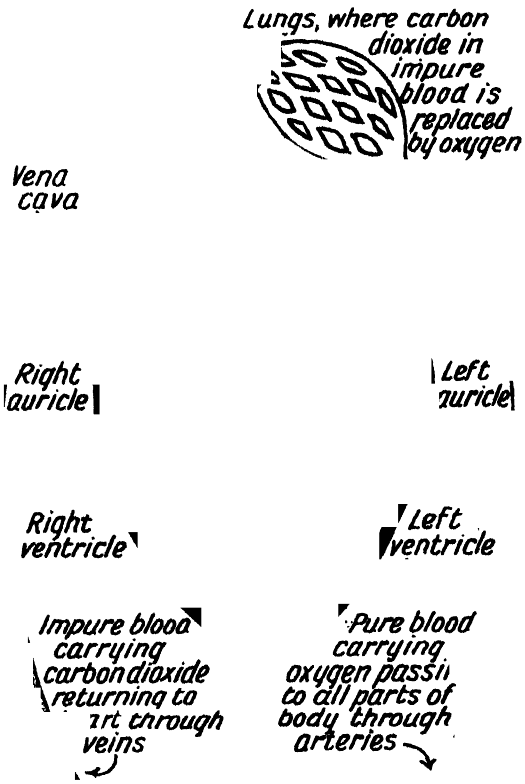
One Way Traffic

Valves at various places prevent the blood going the wrong way, so that the circulation is kept always in the same direction. It is a marvellous system, and in another part of this book we read some interesting things about the rate at which the blood travels through our bodies, and the actual amount of work that the heart does.

The ventricles have much more and harder work to do than the auricles. All the auricles have to do is to fill the ventricles, which offer no resistance to that process, and so while valves are needed between the auricles and ventricles, none is required between the auricles and the veins. The auricle walls are thinner than those of the ventricles.

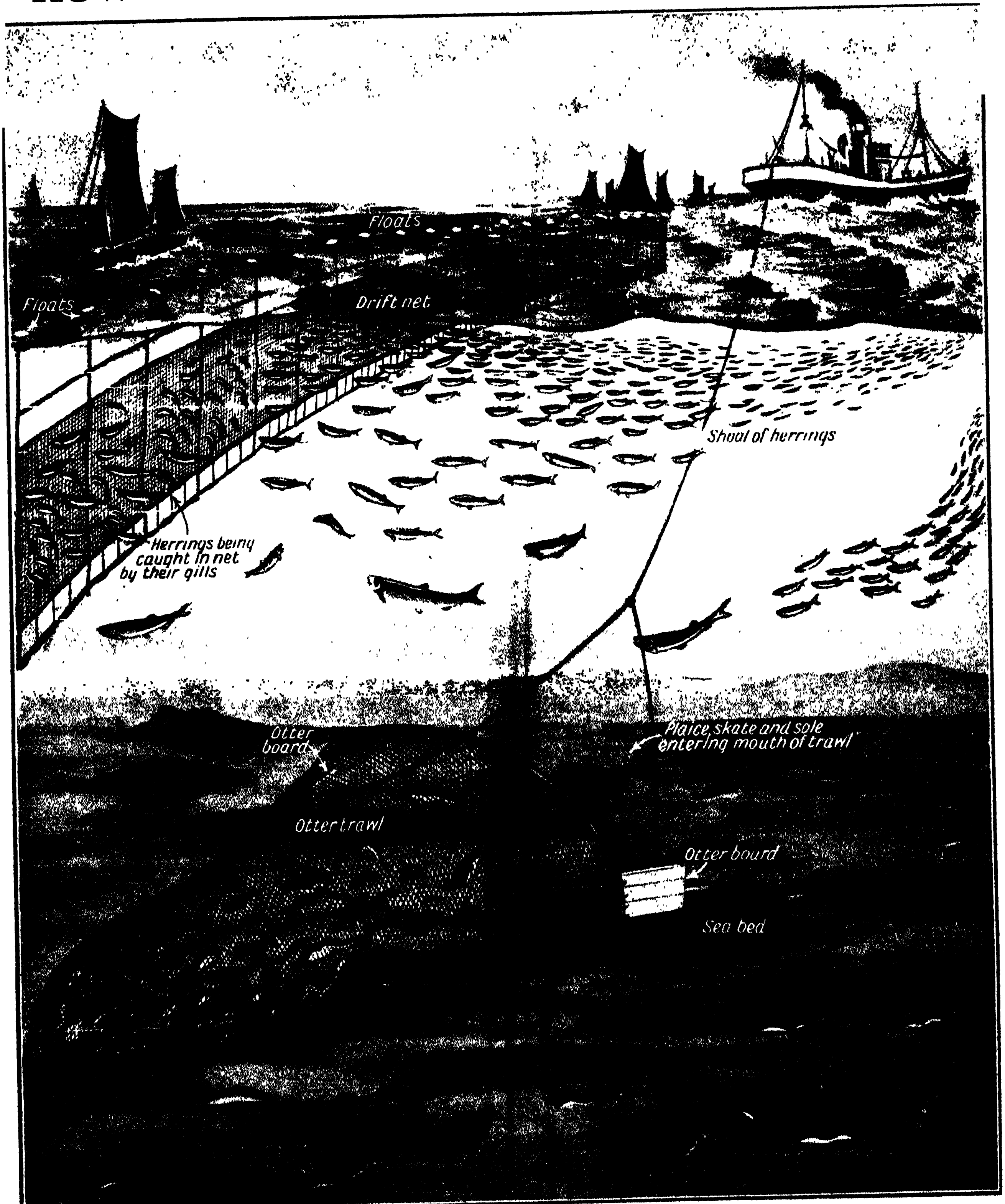
Seeing how important the work of the heart is and how dependent we are for life and health upon its continuing to do its duty, we can well understand what a blessing it is to have a healthy heart and how we should endeavour in every way to keep our heart healthy. If the pump goes wrong the supply of blood on which our life depends must fail or be impaired. Then our health suffers.

When young people indulge in cigarette smoking, and indeed when older people smoke to excess, or when they take much alcohol, they are damaging the heart. It cannot beat properly or do its work as it should.



In this diagram we see in simple form how the blood circulates through the body and is purified in the lungs. We are supposed to be looking at the heart and blood vessels of a person who is facing us. As it comes from the lungs loaded with oxygen and freed of impurities, the blood enters the chamber known as the left auricle, from which it passes into the left ventricle and is pumped through the arteries to all parts of the body. Then it passes through the very small blood vessels called capillaries and into the veins. By this time it has lost its oxygen, and is loaded with carbon-dioxide gas. It passes through the vena cava or large vein into the right auricle, and thence into the right ventricle, from which it is pumped to the lungs. In the lungs the carbon-dioxide is replaced by oxygen, and the purified blood now starts on its round once more

HOW THE FISH OF THE SEA ARE CAUGHT



In this picture we see how the fish that live in the sea are caught in enormous numbers for the food of mankind. The fish that swim in the upper layers of water, such as the herring, mackerel, pilchard and sprat, are caught by means of a drift net. This is shown in the upper part of the picture. The drift net is forty feet deep and often hundreds of feet long, and it is kept floating about nine feet below the surface of the sea by means of floats. The herrings or other fish which swim in shoals are intercepted and caught by their gills in the net and are thus entrapped. Fish that live in deeper water, such as the cod, plaice, turbot, whiting, sole, haddock, brill, skate, hake, gurnard and ling, are caught by the trawl net shown in the bottom of the picture. The mouth of the net is kept open by two boards known as otter-boards, and it is dragged by the steam trawlers over the sea-bed, catching up the fish as it travels

THE LIVELY HEDGEHOG AND ITS ARMAMENT

The most curious of all our British wild animals is undoubtedly the hedgehog, and it could not be mistaken for any other. No other native animal has such a strange means of defence, and if we come upon a hedgehog on its travels during the dusk of the evening we have only to touch it to see how well it defends itself.

It does this on the same principle as the Austrian soldiers, at the battle of Sempach in 1386, defended themselves from the Swiss. They presented a bristling array of lances in all directions, so that the Swiss could not break through their line, and it will be remembered that Arnold de Winkelried broke the line by throwing himself upon the spears and bearing them down, thus by his death making an opening in the defence.

Well, the hedgehog at the approach of an enemy rolls itself up into a ball and the sharp spines with which its body is covered stick out in all directions, so that any foe touching it is pricked by the sharp points. Further, the hedgehog vibrates the spines every moment, which makes them seem more formidable.

A Cure for Cockroaches

The hedgehog is a little animal, about ten inches long, and weighs about a pound and a half. It has short legs and a pig-like snout. Its chief food consists of worms, slugs, snails and insects, and a kitchen infested with cockroaches will soon be cleared if a hedgehog be kept there. It is curious that a number of people suffering from the cockroach pest in their homes, instead of obtaining a hedgehog, buy a tortoise, which can be no good at all, as it is a rigid vegetarian. But the hedgehog's diet is entirely animal; and Gilbert White, accurate as he was in most of his observations, slipped when he endowed the hedgehog with vegetarian tastes.

It used to be said that the hedgehog climbed fruit trees and carried off the fruit by impaling it on its spines, dropping to the ground and suffering no harm as the spines, by their elasticity, broke its fall. It is true that the spines serve this useful purpose of protecting the hedgehog if it falls from a height, but the animal certainly never climbs a tree for the fruit, which it never eats.

The hedgehog is a nocturnal animal, and remains in hiding during the day. It will sometimes raid a hen-house for the eggs, but in a market garden it does good service by devouring harmful insects. It also has a taste for mice and young rats, and is believed occasionally to take baby rabbits.

The hedgehog pairs for life, and a family of from five to seven little animals appears early in August in the nest, which is made of dead leaves. When first born the little hedgehogs are blind, and the spines are both white and soft, but they soon get hard and become grey in colour.

By its prickly weapons the hedgehog can keep off most enemies, including even dogs, but the fox is said to make it unbend by pushing it into the water.

The hedgehog, strange as it may seem, is able to kill grass-snakes and adders. Dr. Buckland tells us how this is done. He suspected that hedgehogs, occasionally at least, preyed on snakes, and so he obtained a grass-snake and a hedgehog and put them into a box together. Whether or not the snake recognised its enemy was not apparent, but it did not dart from the hedgehog, but kept creeping gently round the box. The hedgehog was rolled up and did not appear to see the snake.

A female hedgehog with its family of young ones

Dr. Buckland then laid the hedgehog on the snake, with that part of the ball where the head and tail met downwards, and touching the reptile. The snake proceeded to crawl. Then the hedgehog opened slightly and, seeing what was under it, gave the snake a hard bite and instantly rolled itself up again. It soon opened a second and then a third time, repeating the bite, and at the third bite the back of the snake was broken.

This done, the hedgehog stood by the snake's side and, passing the whole body successively through its jaws, cracked it and broke the bones at intervals of half an inch or more, by which operation the snake was rendered motionless. The hedgehog then placed itself at the tip of the snake's tail and began to eat upwards as one would eat a radish, without intermission, but slowly, till half the snake was devoured. The following morning the remaining half was similarly eaten up.

The flesh of the hedgehog provides excellent food, and it is eaten in many parts of the Continent, and also by gipsies in England.

The voice of the animal, which is rarely heard, is a queer sort of sound between a grunt and a piping squeak. Shakespeare refers to this in one of the witch scenes in "Macbeth," where he says: "Thrice and once the hedge-pig whined."

The Fallen Nestling

Some time ago a gentleman was passing under a rookery when he was attracted by a young rook on the ground, which had fallen from its nest before it could fly, and was making a great noise, squawking lustily. He went to the spot, and was astonished to see a hedgehog which had seized the bird by the back and was worrying it. No doubt it would soon have finished off the young rook had not the gentleman rescued the bird and driven off the hedgehog.

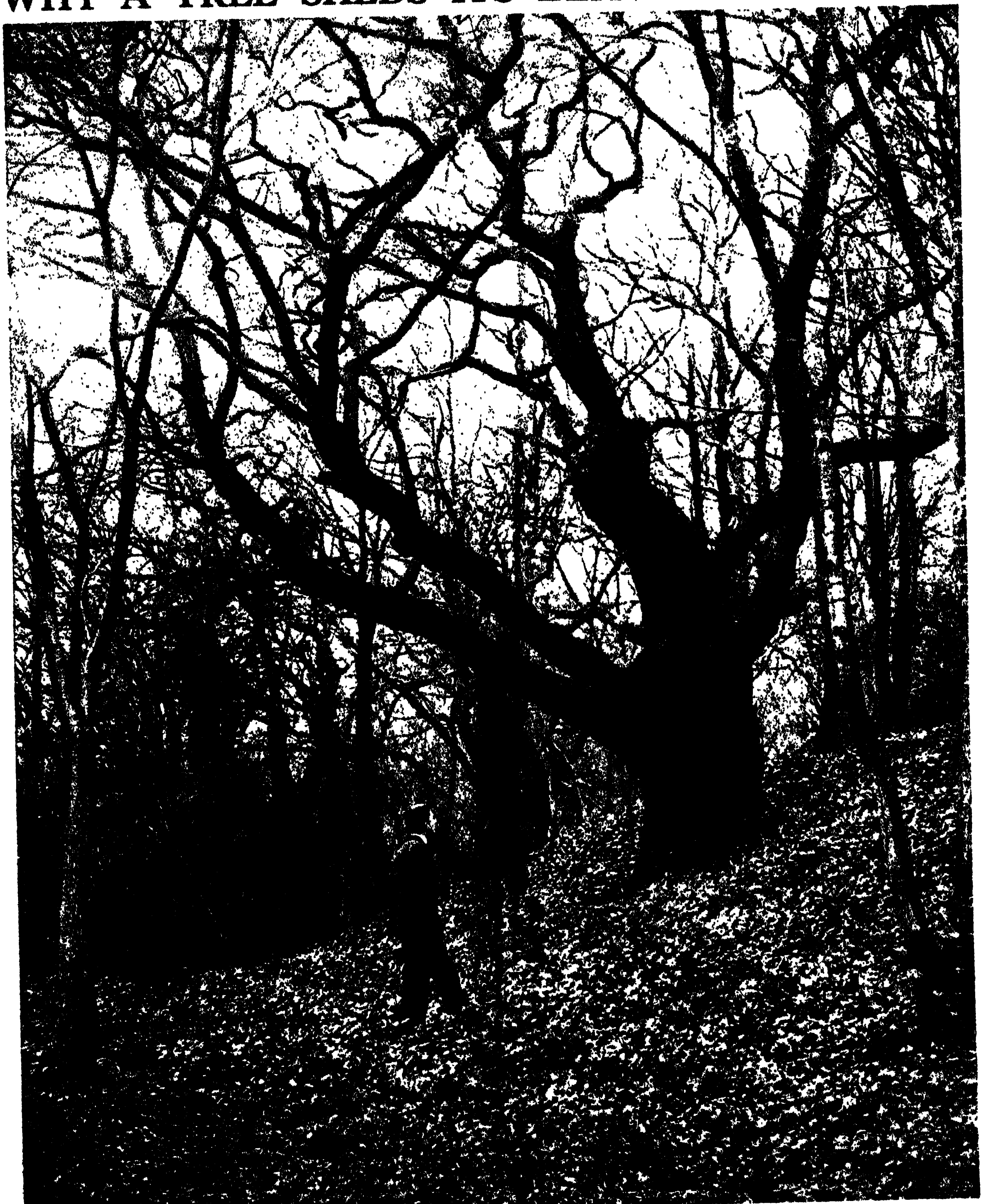
These animals can move very rapidly.

One moment they will be rolled up into a ball, and a moment later will have darted like lightning up the garden path. They are also good climbers, and can even climb up the leg of a kitchen table or an almost perpendicular wall.

It has long been said that at night the hedgehog goes up to cows lying in the fields and sucks the milk from them. Many excellent authorities maintain this stoutly, while others deny it with equal emphasis. The truth or otherwise is still unsettled, but it is quite possible that what happens is that the hedgehog merely goes up and laps up milk which has oozed from a cow needing milking.

If you come across one hedgehog you are pretty sure to find another, for they live in pairs all the year round. Early summer is the time to search for the nest which is made of grass, moss and leaves.

WHY A TREE SHEDS ITS LEAVES IN WINTER



Most of the trees that grow in a country like England with its genial summers and blustering winters shed their leaves as winter approaches. This is a wise provision to save the trees from danger when strong winds blow and snow falls. Without its leaves a tree presents far less surface to the wind and is less able to collect snow on its boughs and branches. It thus runs much less risk of being broken down than it would if it kept its leaves in winter. The frost, too, would do harm to leaves that were trying to carry on their functions. Before the leaf falls a layer of corky tissue forms across the base of the leaf-stalk and protects the scar. Trees like the fir, that keep their leaves in winter, have small, needle-like leaves that present a very small surface to the winds and snow.

AN ARCTIC SCENE IN AN ENGLISH SUMMER

One would hardly think, in looking at this picture, that it represents a scene in England during the warm weather. Yet such is the case. The photograph was taken at the Cambridge Low Temperature Research Station, where men of science carry out all sorts of experiments in connection with the preservation of foodstuffs, animal and vegetable, by refrigeration. So cold is the temperature in these research chambers that the scientists have to wear Arctic clothing such as explorers would wear on a trip to the North or South Pole. The intensely low temperatures required are obtained in the way shown on pages 624 and 625 of this book. Some substance like ammonia or carbon-dioxide gas is compressed and in the process it takes up a good deal of heat. Then the warm compressed gas is cooled by passing through pipes over which cold water is flowing. It is then allowed to expand, and in doing so gives up much more heat so that it becomes intensely cold and then liquefies and runs through pipes in the refrigerating chambers. The very great cold it produces can be realised by the frozen moisture on the outside of the pipes in the room shown in the photograph. Even where these pipes containing the cold fluid run through a warm engine-room so cold are they that they become covered with artificial ice and snow in the warm room

ATOMS NOW WORK IN OVERALLS

As we read in this article, there are many applications of atomic science that have nothing to do with the atomic bomb. Indeed, the peaceful applications of the atom now greatly outnumber its military uses, and the results of nuclear fission have come to play an increasingly important part in the everyday work of the world.

Scientists at Michigan University, U.S.A., have discovered a way to preserve food by treating it with atomic rays. The rays exert a preservative action by destroying the bacteria responsible for decay and putrefaction, and will eventually save millions of pounds a year now lost through foodstuffs that go bad.

Preserving food is only one of the many applications of atomic science which remind us that nuclear fission is something more than being the most destructive weapon of war. Indeed, the peaceful applications of the atom now far outnumber its military uses.

Consider, for example, the phenomena of isotopes, the use of which has become a commonplace of many industrial and engineering processes. First, however, a word as to what isotopes are, and the peculiar properties that render them of such service to the engineer and manufacturer

Unstable Elements

Besides the ordinary stable chemical elements contained in every substance in the earth and in the universe, there exist certain other elements which, being in a constant state of motion, break up and release various forms of radiation in the same way as does radium These unstable elements are called radioactive isotopes, and they differ from the stable elements only by theirpr operty of radiation; otherwise their chemical behaviour is identical.

Even the most minute quantity of a radioactive element such as radium will betray its presence for many years when mixed with something else. The quantity may be as little as a millionth of a gramme in many millions of gallons of water; but the presence of radioactivity will always be revealed by means of a suitable detector

An example is provided by the luminous dial of a watch. Although the radium mixed with paint is only one part mixed with many millions of parts of paint, it betrays its presence by causing the paint to glow in the dark.

Unfortunately, radium, even in the very tiny quantities necessary to make a paint luminous, is far too scarce and expensive for general industrial application. Moreover, there are many applications where a permanent glow such as that from luminous paint would be most undesirable.

Consequent upon the work that resulted in the atomic bomb, it was found that a number of the stable or non-radiating chemical elements can be made radioactive by so treating them in a nuclear pile that their atomic balance of electrons and protons is thrown out of balance.

In other words, the element has been given a difference of electrical potential and generates an electrical current in the form of radiation; that is, it becomes to all intents an invisible broadcasting station.

Actually, an unstable element is one in the process of disintegration, or breaking up and turning into something else, and it is the process of disintegration that causes it to emit radiation. Thus the radiation from radium is due to that unstable element being in the process of turning into lead, which is a stable element.

Radiations produced by radioactive elements may be of three kinds: alpha particles, which are doubly charged nuclei of helium; beta particles, which are fast moving electrons; and gamma rays, which are electro-magnetic radiations similar to X-rays but more penetrating. Beta particles and gamma rays, are the radiations chiefly produced by artificially-induced radioactive elements, or, as they are called, isotopes.

All these radiations, no matter how small their concentration, are easily detected by special recording instruments, such as Geiger counters.

One of the most novel uses of isotopes was recently made in the north of England where it was thought that a lake holding some millions of gallons of water might be leaking into a coalmine.

To make certain, however, a kilogramme of salt containing radioactive sodium was thrown into the lake, and a detector placed beside the spot in the mine where water was seeping in. When the water leaking through showed traces of sodium it was proved beyond doubt that the lake was gradually seeping into the mine.

In the textile industry it is essential that a uniform coating of oil should be applied to fibres before they are woven. The amount of oil necessary is extremely small, about one-millionth of a gram per inch of fibre, but if the oil coating is uneven, weaving will be faulty, while the finished fabric will have a patchy appearance when it is dyed.

Hitherto, the only method of measuring the amount of oil on the fibre has been to take the average coating on several inches of fibre. This, however, gives no guarantee that the oil is evenly coated over the fibres.

Now it is possible to add a minute quantity of a radioactivated element called ethylene dibromide to the oil before it is applied to the fibres. The activated oil is then coated on the fibres, and the fibres stretched over a revolving drum covered with a photographic emulsion.

This results in a radiograph which gives a true indication of the thickness of the oil over as little as one-hundredth of an inch of fibre. The trace element or isotope reveals its presence wherever the most microscopic drop of oil has adhered to the fibre.

Similar application of isotopes to oil are used in refineries where purified oil is piped through a single pipe system for filling into containers according to quality. Where the pipelines are of considerable length, the change of grade at the sending end of the system will reach the receiving end after the lapse of some time

Sampling Oil

Unless a long and complicated chemical sampling programme is carried out as the oil flows from the pipe, it is impossible to determine exactly when the change-over to the containers should be effected. But by injecting a suitable isotope as the first of the new grade of oil is pumped in, the front of the new grade is effectively labelled. A detector at the receiving end of the pipelines then immediately indicates the presence of the isotopes when the front of the new grade of oil arrives.

Beta radiation is extensively used for automatically testing the thickness of films made from various materials. A trace element is incorporated in the material from which the film is being made and a beam of beta particles is then projected through the film.

Any thickened portions of the film blocks a certain number of the particles, and a detector will then record the number of particles so blocked; the thicker the material, the greater is the number of particles stopped.

Electronic engineers have linked the detector with a brake which

automatically stops the manufacturing machine when the concentration of beta particles, and therefore the thickness of the fibre, exceeds a certain fixed limit.

Some types of film are made to such fine degrees of thickness that there is no mechanical measuring instrument capable of detecting small but important variations.

Isotopes have been equally successful in determining how the various metals composing an alloy are distributed. Thus, in the case of phosphor-bronze it is essential that the phosphor shall be absolutely uniformly distributed throughout the bronze if the alloy is to have the correct properties of strength and wear.

Before the alloy is melted and cast into ingots, a radioactive isotope is introduced into the phosphorus. When the ingot has cooled, an X-ray photograph is taken, and from this it is possible to determine whether or not the phosphorus has been correctly absorbed into the structure of the alloy. Equally striking has been the use of isotopes to prevent fire due to accumulated static electricity. In certain machinery, particularly mechanical conveyors, moving belts of insulating material pick up large quantities of static electricity as they pass over metal or insulating rollers.

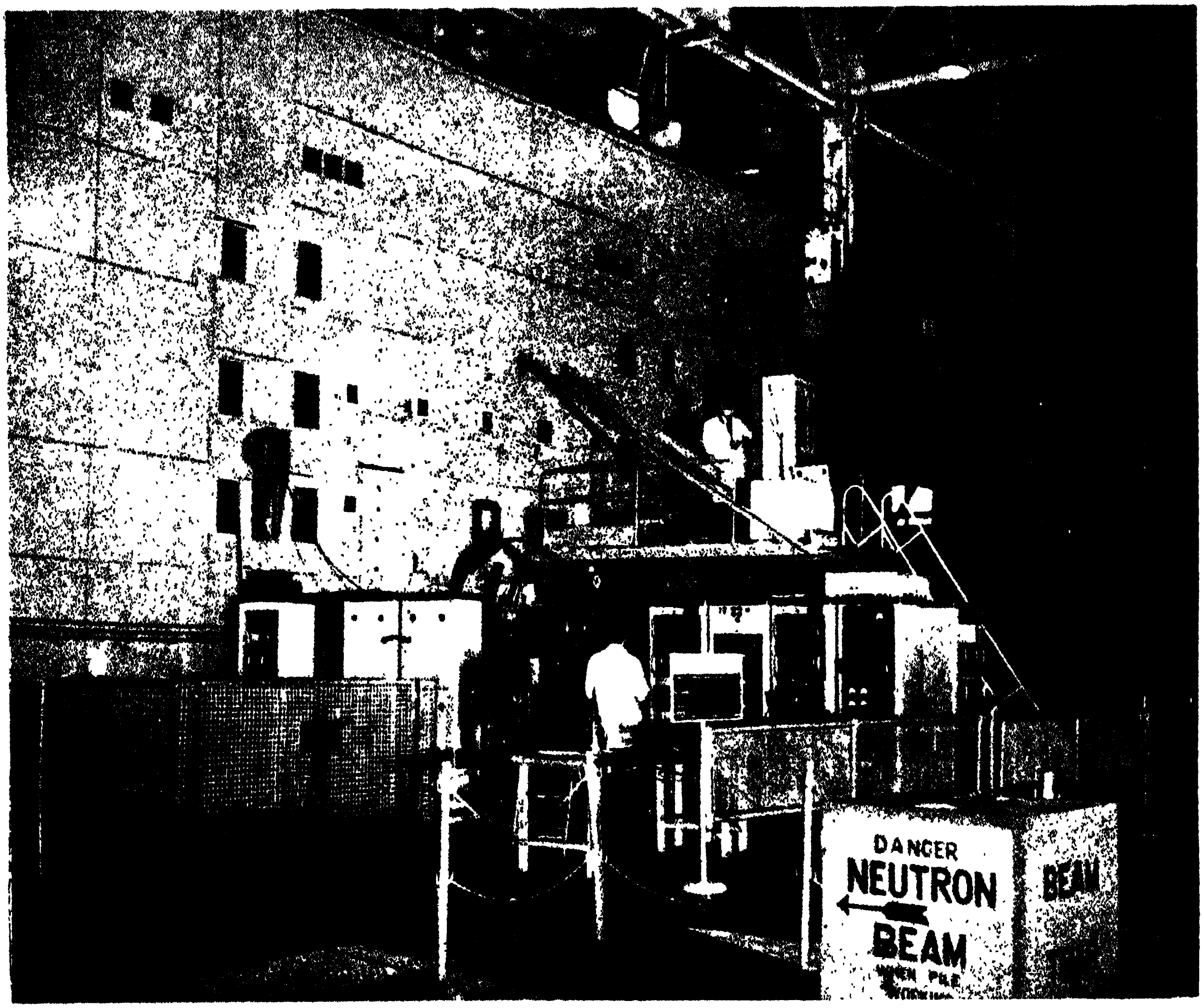
Failure to get rid of the static electricity can result in the building-up of a current until it generates a spark which may ignite any inflammable vapours or liquids in the vicinity. Hitherto the accepted method of getting rid of static electricity has been to conduct it to earth by various discharging devices, but these are costly to install and maintain, and are liable to break down.

If, however, a radioactive isotope such as thallium or trontium is placed close to the source of static charges, a stream of beta particles will be emitted. The beta particles have the effect of ionizing the air over an area of several square feet, and through this ionized air the static charge will leak harmlessly to earth.

Finally, isotopes have solved one of the most time-wasting difficulties in surveying. When making surveys it is frequently necessary to drive marking stakes into the ground for future reference, and if the survey is being made over farmland the stakes must be driven several inches below ground level to prevent their interfering with ploughing or injuring cattle.

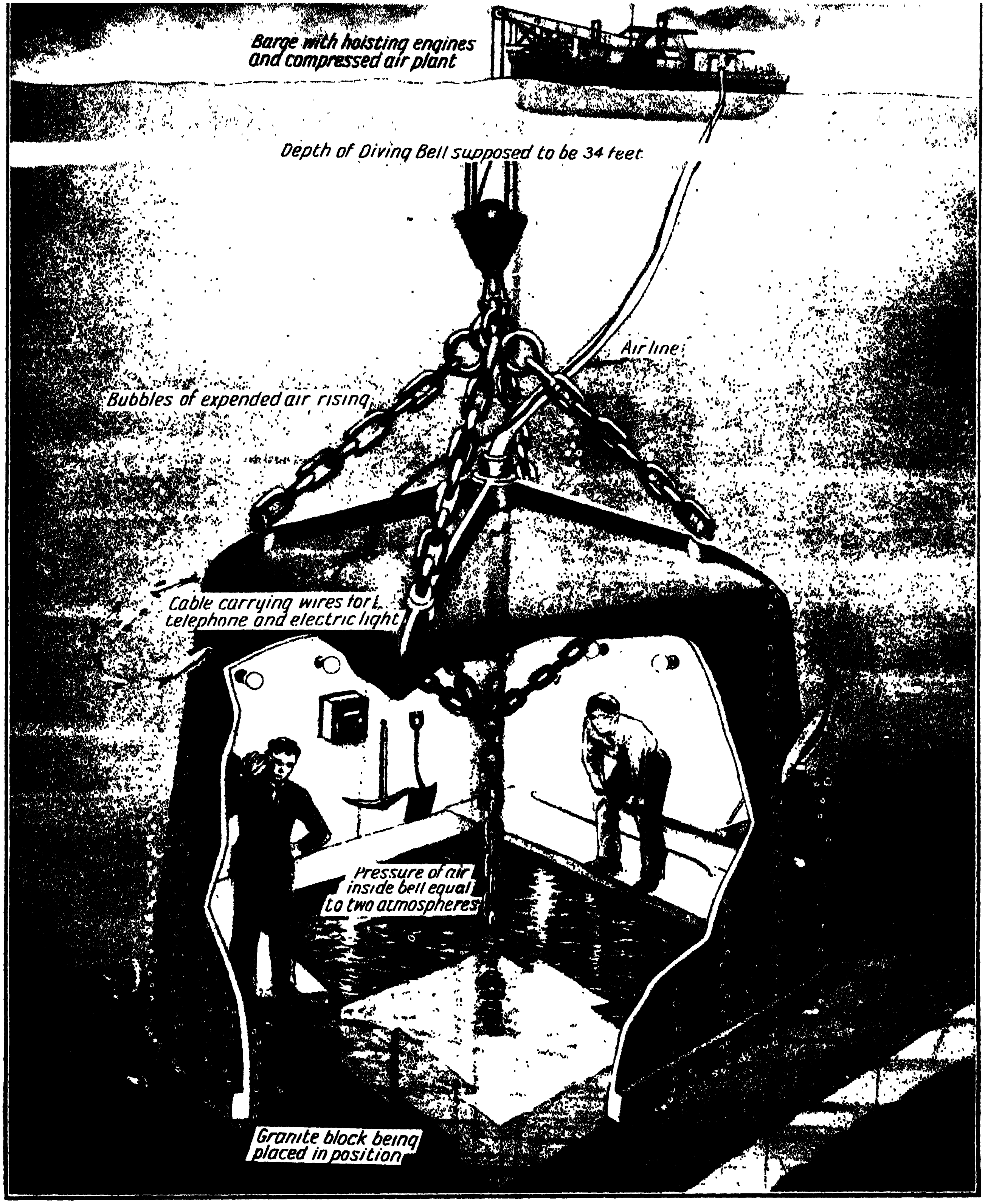
Consequently when the marking stakes are again required it may entail a new survey to locate their approximate position, and an area of several feet in diameter must be dug to find them.

Many surveyors now fix into the top of their stakes a disc of metal containing an isotope trace. This isotope can then be detected by a Geiger counter many years after the stake has been driven into the ground, and despite the fact that it may be covered with several feet of earth or vegetation.



This photograph shows part of the atomic pile at the British Atomic Energy Research Establishment at Harwell, Berkshire. The pile is used in the production of some of the industrial isotopes described in the article on this and the previous page.

WHAT A DIVING BELL IS LIKE INSIDE



A diving bell is a steel chamber with electric light and telephone, and with an air-line through which compressed air can be pumped from a barge above. Here a block of granite is being laid for a pier foundation. Each block is suspended from a chain inside the bell which is then let down by a crane, the men inside directing the block to the correct position. The air pressure in the bell must be equal to the water pressure outside, otherwise the water would rise. This diving bell is supposed to be 34 feet down where the pressure is equal to two atmospheres. Some diving bells have an air-lock for the men to pass through and get used to the pressure. Tradition says that Roger Bacon invented the diving bell in the 13th century, but the earliest authentic record is of one in Spain in 1538

EXPERIMENTS IN THE SCIENCE OF SOUND

There are many simple experiments which can be carried out without special apparatus, and which help us to understand the science of sound.

If we take an ordinary wineglass and, holding it lightly by the base, flick the top of the glass with our finger, we shall hear a bell-like sound. This is due to the fact that by flicking the

Setting a glass vibrating

glass sharply with our finger-nail we have set it vibrating very rapidly. The vibrations set up waves in the air and these striking upon the drums of our ears send a message to our brain which we interpret as sound.

We can carry out another interesting sound experiment by using two glasses

A wire set dancing by sound waves

which are alike. We put water into them to a depth of about one quarter. We then flick them as before to get a note. If the note varies in the case of the two glasses we put a little more water into one till we have brought their notes to the same pitch.

Now when the glasses are in tune with one another we lay a thin piece of wire with the ends bent across the top of one glass. If we now flick the glass without the wire, or run our moistened finger round the rim, we shall set it vibrating, so that it gives a musical note, and what seems very strange, the

The hands used as a megaphone

wire on the other glass will begin to dance up and down.

The explanation is that the two glasses being in tune, when one is set vibrating the other also vibrates in sympathy, and it is the vibrations of the glass that cause the wire laid across it to dance.

We know that if we want to make a person at a distance hear what we say when we call aloud to him we place our hands one on each side of our mouth. When we do this we are really carrying out a scientific experiment, for by placing our hands so as to form a kind of funnel we prevent the sound waves from being dissipated at the sides and our voice will carry farther. Our hands, in fact, form a kind of megaphone.

How sound waves become dissipated when there is nothing to prevent them spreading can be shown by the

A miniature motor-horn

experiment of ringing a bell in a garden and then the same bell in a room. It sounds much louder in the room, because the sound waves instead of spreading out indefinitely are reflected backwards and forwards by the walls, floor and ceiling of the room.

Here is an interesting sound experiment which can be carried out with a little apparatus that any boy or girl can make. We take a tin cylinder, such as the body of a tin canister, with the bottom removed, and over the top we stretch a piece of parchment or grease-proof paper, tying it round tightly to

Sound waves dissipated in the open air

keep it in position. We then fasten a string to the middle of the parchment, passing it through a hole and making a knot on the other side to prevent it from slipping out.

Now, with a little resin on our fingers, we draw them along the string. There is a surprisingly loud noise,

Sound waves reflected in a room

something like that of a small motor horn. What happens is that our resined fingers, pulled along the tightened string in little jerks, set the parchment vibrating and the tin acts as a resonator.

The reason for putting resin on our fingers is to increase the friction between them and the string. Without it our fingers would slip too easily over the string and cause little vibration.

THE GREATEST REVOLUTION OF ALL

Here is the story of the greatest of all revolutions which has come to be known as "the Industrial Revolution." It transformed England and later spread to all other civilised countries, including Russia, which is now in the throes of its industrial revolution. But England went through its transformation more than a century ago, the first land to be industrialised on modern lines

HISTORY records many dramatic revolutions which have changed not only the form of government but the course of history. But of all the revolutions of which there is any record none has had more momentous consequences and lasting effects than a revolution that took place in England.

Yet it was a revolution in which there was no fighting or bloodshed, in which no great principle of government was at stake, and in which no ruler was turned off his throne or statesman driven from office.

Life Completely Changed

It is known in history as the Industrial Revolution, and it took place in the eighteenth century. As the result of a number of inventions, all made in Great Britain, the whole course of the economic and industrial life of the country was completely changed. Home industries perished, and factories grew up to do the work of the nation. People became "hands," and lost all individuality and economic liberty, just as though they had been legal slaves on a West Indian plantation.

In some ways it was a dreadful revolution, and probably led to more deaths and more misery than any other revolution that has ever taken place. Men became callous and cruel beyond conception, and the greatest sufferers were boys and girls and little children.

Up to about the middle of the eighteenth century there were no factories, and all such work as is now done in factories, spinning, weaving, and so on, was done in the homes of the people or in small workshops. Near by were plots of ground, which the workers cultivated when they were not busy, and on which they grew a great deal of their food. Spinning was done by hand, and weaving also, and there had been scarcely any change in the methods of work for centuries.

As the population increased and more cloth was required for clothing, the demand for spun thread, which could be woven, increased, but the old methods of hand spinning could not keep up with the demands of the weavers.

This set ingenious men wondering whether some machine could not be devised which would spin the thread more quickly than it could be spun by hand.

In 1773, John Kay, a Lancashire man, who was the son of a woollen manufacturer, had invented what was called a flying shuttle for weavers. Up to that time the shuttle carrying the weft or cross-threads had to be passed to and fro along the warp or threads stretched lengthwise in the loom, in order to make the cloth, and for this process the weaver's two hands had to be used. The width of the cloth was therefore limited by the stretch of the weaver's arm, or required two men to do the work.

Kay's invention enabled the shuttle to be propelled by cords attached to a stick or lever, which the weaver held in his right hand. From the speed with which the shuttle could be thrown and cloth woven the invention obtained the name of the fly-shuttle.

The result of the invention was that a weaver and loom could now produce double the quantity of cloth and also make it of a better quality. It was first used in the woollen industry.

But poor Kay, a very ingenious man, gained nothing from this and his other inventions for the carding and spinning of wool. The workmen whom he meant to benefit rose in opposition to his invention, believing that it would deprive them of work, and they mobbed him.

A Luckless Inventor

He went to Colchester, where he managed a woollen factory, till he was driven from that place also by the workpeople. Then he went to Leeds and set up as an engineer, but the Yorkshire clothiers treated him shamefully, using his shuttle, but paying him no royalty on his patent, and they combined to form a Shuttle Club to swindle the inventor.

Wherever he went Kay was the subject of hostility and hatred, and at last the workpeople forced him to close his machine shops. When he returned to his native town of Bury, hoping to find friends there, the mob broke into his house, smashed all his furniture and implements, and would probably have killed him had not a couple of friends wrapped him in a woollen sheet and carried him out to a place of safety.

For ten years he wandered about, trying to get justice, and then, worn out and with no means left, he went to France. He was unable to earn a living there, so returned to England

Samuel Crompton, inventor of the spinning mule

Richard Arkwright, inventor of the roller spinning machine

James Watt, who improved the steam-engine

Edmund Cartwright, inventor of the power-loom for weaving

and tried to get some reward for his invention from the Government But the Government would do nothing for him, and Kay went back to France where he died a pauper in 1764

He wrote just before his miserable end: "I have a great many more inventions than what I have given in, and the reason that I have not put them forward is the bad treatment that I had from woollen and cotton factories in different parts of England twenty years ago, and then I applied to Parliament and they would not assist me in my affairs, which obliged me to go abroad to get money to pay my debts and support my family."

It was Kay's fly-shuttle which speeded up the weaving of cloth and led to the ever increasing demand for thread, thereby giving an impetus to the invention of spinning machinery

The beginning of modern machinery in the spinning industry may be dated from the invention by James Hargreaves, an illiterate weaver of Standhill, near Blackburn, of the spinning jenny. The name "jenny" is by some said to be a corruption of "ginny," which comes from the word "gin," an abbreviation of "engine," but by others it is said that Hargreaves named his machine a "spinning jenny" because his wife's name was Jenny.

A Lucky Accident

Hargreaves was waiting one day for the weft or thread which his wife was spinning on her wheel when the wheel fell over on its side, and the spindle was thus thrown from a horizontal position into an upright position. Wheel and spindle went on revolving, and this gave Hargreaves the idea that by widening the wheel and placing a number of upright spindles in a row, he might be able to spin several threads at the same time.

The people, becoming jealous of his extraordinary output, broke into Hargreaves' house and smashed up his spinning jenny

He made a frame with eight spindles and the machinery for feeding them. The apparatus worked well, and for a year or two he used it in his own house, producing eight times as much yarn as before.

The speed with which the Hargreaves produced their material at first astonished their neighbours. Then these people became jealous, and finally broke into the house and destroyed the jenny.

Hargreaves was compelled to leave Blackburn, and went to Nottingham, where with a partner he set up a small mill. Here he increased the number of spindles on his jenny from eight to sixteen, and he patented the machine in 1770. The device was so good that it very soon came into general use. Hargreaves went on improving the machine, till he had increased the number of spindles to 120 or more.

The workers, however, who were engaged in spinning, became alarmed for their livelihood, and began to cause riots. But the clever device was so useful that it could not be suppressed, and fortunes were made out of it, though not by Hargreaves, for his patent was constantly infringed by dishonest people. He, however, made a few thousand pounds, but after his death some of his children were in great poverty, and when a fund was raised to preserve them from destitution, the wealthy manufacturers of Lancashire who had grown rich out of Hargreaves' invention would scarcely give anything at all.

It may certainly be said with truth that never was an invention more timely. It came at the very moment when the demand for spun thread was most insistent. This makes the treatment of Hargreaves the more disgraceful.

The next great name on the list of men who brought about the Industrial Revolution is that of Sir Richard Arkwright. He was one of the few pioneers who gained wealth and fame from his work but it is doubtful whether he, like the others, was really an original inventor.

Born in humble circumstances, Arkwright was apprenticed to a barber, and being of an enterprising disposition, he began to travel up and down the country, visiting the hiring fairs, where young girls were seeking posts as domestic servants. He used to buy their hair, and then dye it by some secret process of which he had knowledge, selling it to the wigmakers. But wigs were falling into disuse, and Arkwright, being a far-seeing man, turned his thoughts in other directions.

He often came in contact during his travels with the weavers and spinners, and he soon learned that the thread spun by the jenny, while being suitable for the weft in weaving, was not strong enough to be used for the warp. He thought over the matter and decided that it should be possible to produce a machine which would make suitable warp thread.

Rollers instead of Wheels

Some years before, that is in 1733, a man named John Wyatt made a model of a machine about two feet square, in a small building near Sutton Coldfield in Warwickshire, with which he spun cotton thread even before Hargreaves invented his jenny. In this model the fibre, instead of being passed twice round the spinning-wheel, was drawn between a pair of revolving cylinders, one plain and the other fluted, and then passed immediately between another pair of rollers, so arranged that they would revolve more quickly than the first pair.

Wyatt was induced to transfer his invention to an acquaintance named Lewis Paul, who patented it in his own name in 1738. Some money was obtained from a bookseller, and a small mill was started at Birmingham with one of Wyatt's spinning machines worked by two asses walking round and round, while ten girls attended to the machine.

The enterprise, however, was a failure, but the machine was tried again on a larger scale at Nottingham, the power being supplied by water, and

fifty hands working 250 spindles. This too failed. The machinery got out of order, and the idea was forgotten, Hargreaves' jenny having proved much more successful.

But the idea of the rollers was revived by Richard Arkwright, who got a clockmaker named Kay to make certain models for him. After some experiments a spinning machine was constructed with rollers, and set up in a secluded room in a house hidden by trees at Preston.

The neighbours, owing to this secrecy, became suspicious, and in that superstitious age connected the proceedings in the house of mystery with witchcraft. Two old women declared that they had heard a strange humming sound coming from the house, as if the Devil were tuning his bagpipes, and Arkwright and Kay were dancing to the music.

Frightened Neighbours

The consternation in the district grew rapidly, and there was some talk of breaking into the house. But Arkwright, anxious that his machine should not suffer the fate of that of Hargreaves, removed to Nottingham, where he entered into partnership with others, erected a spinning mill and took out a patent for his machine in 1769—the same year that James Watt took out his first patent for the improvement of the steam engine. How little these men realised that they were bringing about a great revolution!

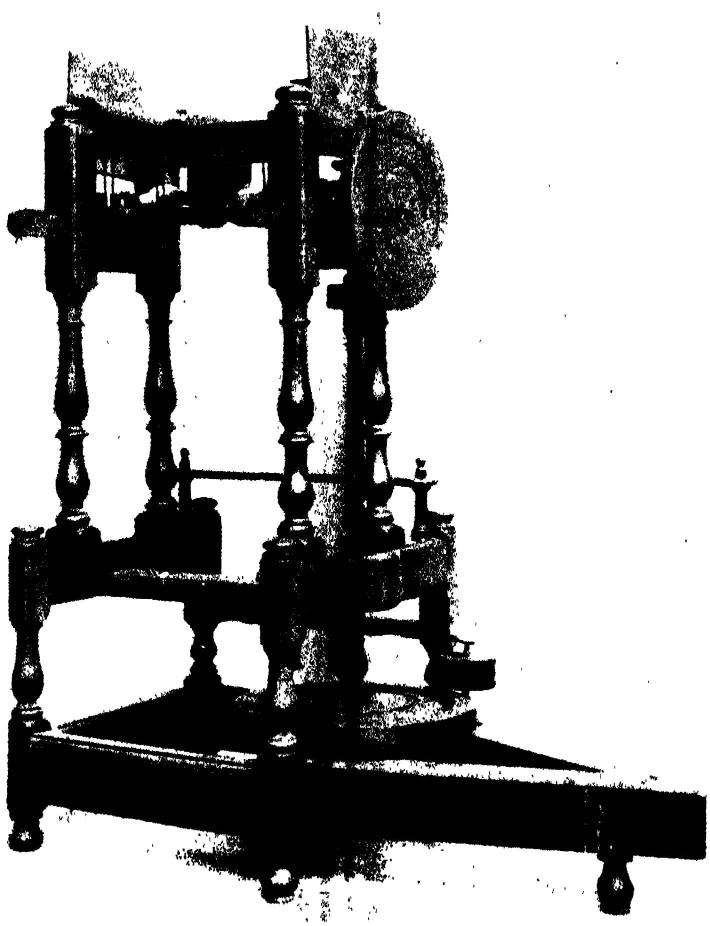
Arkwright's first spinning mill was driven by horses, but as such power was expensive and could not be applied on a large scale, he decided to get other partners and erect his spinning frame, as it was called, in a place where it could be worked by water power. This was at Cromford in Derbyshire.

The yarn produced was very hard and firm and eminently suited to be used as warp. But the conservative Lancashire manufacturers would not make use of it. It was therefore used at first for the making of stockings, but very soon it came to be utilised in the manufacture of calico.

Arkwright built several other cotton mills, and being a good business man, sold grants for the use of his patent to great advantage.

Then the old trouble arose. The workers became alarmed, serious riots broke out in Lancashire in 1779, and a costly mill erected by Arkwright at Chorley was sacked.

This put Arkwright into great financial difficulty, and at the same time spinners began to infringe his patent. He brought actions against a number of firms, and after much litigation his patents were cancelled on the ground that he had only utilised the inventions of others. How far this is true it is difficult now to say, but Arkwright was such an excellent business man that despite the cancelling of his patents he was able by the use of his own machines to beat the other manufacturers. He worked very hard, labouring from five o'clock in the morning till nine at night, and never wasting a moment, and all this despite the fact that he suffered from ill-health.



Richard Arkwright's original spinning machine

Thomas Carlyle has described him as "a plain, almost gross, bag-cheeked, pot-bellied Lancashire man, with an air of painful reflection, yet also of copious, free digestion." His ability and industry were well rewarded, if money and honour are rewards, for he became High Sheriff of Derbyshire, was knighted by King George III, and died leaving half a million of money after he had twice presented each of his ten children with a gift of £10,000.

The year after Hargreaves had patented his jenny, and when Arkwright was building his mill at Cromford, a youth of eighteen named Samuel Crompton was earning his living by spinning on one of Hargreaves' jennies, and weaving the weft on a hand-loom at a house in Bolton called Hall-i'-th'-Wood.

He was an enterprising sort of youth, and made a careful study of the jenny which he was using. Why, he reasoned, should not a machine be devised which could make even better yarn and turn it out more quickly? He spent his spare time in trying to invent such a machine.

The Haunted House

He was rather a secretive youth, and told nobody about his hopes and attempts, but he sat up so late working at his invention that soon his family and neighbours, hearing strange and unaccountable sounds coming from the old house at untimely hours, and seeing lights in the windows, began to get curious. Then word went round that the house was haunted.

Crompton, however, went on for several years in his attempt to improve spinning, and spent every penny he could save from his wages on the invention. He may or may not have heard of Arkwright's roller spinner, but he certainly had never seen such a machine. He adopted the roller principle, however, making his rollers of wood covered with sheepskin, and linked these up with a movable carriage carrying twenty or thirty spindles, which revolved while the carriage was receding from the beam on which the rollers were placed. This spindle carriage was Crompton's great contribution to spinning machinery.

By 1779 he had almost completed his invention, which later came to be called a spinning mule, because just as a mule is the offspring of a mare and an ass, so the spinning mule was a cross between the machines of Hargreaves and Arkwright.

The advantage of having a movable carriage for the spindles was that there was no strain on the thread before it

was completed, and it could be drawn out much finer than by the water-frame or jenny. It has been said that Crompton's mule was the first machine to reproduce the action of the left arm and finger and thumb of the spinner on the ordinary spinning wheel.

Unfortunately, just as Crompton had completed his invention there was a great popular clamour against all spinning machinery, which it was felt caused unemployment among the spinners. The people rose and every jenny for many miles round Blackburn was destroyed, except those that had fewer than twenty spindles

Crompton felt this was no time to produce his invention, so he took it to pieces and concealed the various parts in a garret in the old Hall There they remained hidden for many weeks, but later he put the machine together again and began to spin some very fine yarn suitable for making muslins of the most delicate texture.

Public Curiosity

He married in the following year, and moved from the Hall, but he went on producing yarn there by means of his mule, of such fineness and strength that it soon became famous. The old Hall was soon besieged by manufacturers, some of whom wanted to purchase yarn, but others to discover the mystery of the wonderful new machine.

All kinds of tricks were tried to obtain admission to the house, and many people climbed up on ladders to peep through the windows. Crompton erected a screen round his invention, but one inquisitive person is said to have hidden himself for some days in the cockloft, where he watched Samuel at work through a gimlet hole which he had made in the ceiling.

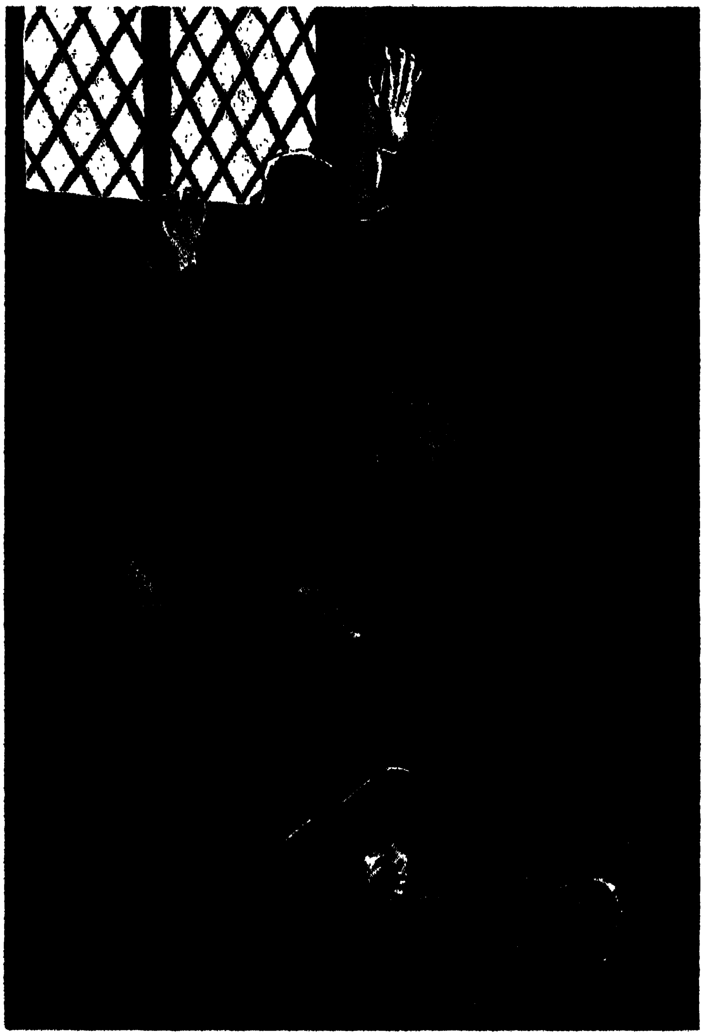
Poor Crompton was too poor to apply for a patent, but he realised that he must either give his invention to the world or destroy it. He decided to do the former, and after receiving promises of money rewards from many manufacturers, who agreed to subscribe to a fund for his benefit, he revealed his secret.

The majority of the scoundrelly manufacturers, however, having won the secret, failed to carry out their promises, and all that was subscribed to the fund was £106. As a matter of fact, Crompton received much less than this. He says: "I received as much by way of subscription as built me a new machine with only four spindles more than the one I had given up the old one having 48, the new one 52 spindles."

The mule was now greatly improved, and soon came into general use. Crompton petitioned Parliament for some recompense for the great gift he had bestowed on the country, but instead of getting £50,000 to which he thought he was entitled, he was granted the inadequate sum of £5,000.

Probably Crompton would have received more, but Mr. Spencer Perceval, the Prime Minister, while on his way to propose a vote of £20,000, was shot by a madman in the Lobby of the House. When the Prime Minister fell he had in his hand a memorandum referring to the proposed vote. The matter was not pursued and Crompton did not receive the larger sum.

How completely Crompton's machine superseded those of Hargreaves and Arkwright may be seen from the fact that in 1810 the number of spindles used upon Hargreaves' jenny machines was 155,810, upon Arkwright's water-frames 310,516, and upon Crompton's mules 4,600,000.



People peeped through the windows to get a glimpse of Crompton's invention

We now come to another name in the group of Englishmen who brought about the great Industrial Revolution. Some time in the year 1784 a number of gentlemen were discussing the recent invention of Arkwright for spinning yarn, and one of them observed that so much yarn would now be produced that there would not be enough hands to weave it into cloth.

One of the party, Dr. Edmund Cartwright, who was a Leicestershire rector, declared that Arkwright would now have to set his wits to work to invent a weaving mill. His friends, however, said this was impossible.

Dr. Cartwright was entirely ignorant of mechanics, and had never even seen a hand-loom, but the idea of a weaving machine had taken a firm hold of his mind, and he decided to try to invent such a machine himself. He did so, and took out a patent in 1785, but the machine was not very good.

Patient Improvement

In the next year or so, however, he improved the machine, took out fresh patents, and set up a factory of his own at Doncaster, for weaving and spinning. It did not prosper, but he went on improving the machine, spending over £40,000 in the task. He also invented a wool-combing machine, the first of its kind, by which even in the early stages one machine could do the work of twenty hand-combers.

At once petitions against the machine were sent up to the House of Commons from 50,000 wool-combers, and Cartwright agreed to limit the number of machines to be used in any one year.

In 1791 a Manchester firm built a mill in which some of Cartwright's power-looms were erected and worked by a steam engine, but the Manchester mill was burnt down by workmen who feared to be thrown out of employment. This prevented other manufacturers for a long time from adopting the power-loom.

Cartwright's patents were infringed a good deal, and he made nothing out of his invention, but after the patents had run out he petitioned the House of Commons, which voted him a sum of £10,000. He retired to the country

and became "a portly, dignified old gentleman, grave and polite, but full of humour and spirit." He went on inventing right up to the end, and when he died at Hastings in 1823 he was buried in Battle Church.

But all this invention of spinning and weaving machinery would have had far less effect in changing the character of English industry if it had not been for another invention, namely, that of the steam engine. With water-power to drive the machinery, the factories were limited to certain specified areas, but the steam engine made it possible to set up a factory anywhere.

It is sometimes said that James Watt, the Scotsman, invented the steam engine. Of course this is nonsense. There were steam engines long before Watt, made by men like Thomas Newcomen of Dartmouth. What Watt did was to improve the steam engine so much that it could be used as an economical source of power for driving machinery.

The result of the invention of spinning and weaving machinery and the improvement of the steam engine was soon seen in the erection of factories all over Yorkshire and Lancashire.

And now began one of the darkest passages in England's history. Women and children could, with the aid of the new machinery, do the work of grown men, so they were employed instead of men, and the working classes for years became little better than slaves.

Cheap labour was required, and wages were brought so low that all the members of the poorer families, including children of five or six, had to labour, to save themselves from starvation. No spinner or weaver could earn enough to keep his family.

Someone thought of the dreadful idea of obtaining pauper children from London workhouses, and under the pretence of apprenticeship binding them to a slavery far worse than any negro slavery in the West Indies. The authorities in London jumped at the idea, and found the scheme for getting rid of hundreds of little mites very attractive. They even insisted that the employers should take one idiot child in every twenty apprentices.

The children were bound to the employer till they were twenty-one years of age. Even in what was regarded as a model mill near Manchester the children were worked 74 hours a week, but in the majority of mills the work lasted fifteen hours a day, Saturday included.

Think of what this means—little children from five to eight years old working from five o'clock in the morning till eight o'clock at night. They were supposed to have half an hour for breakfast and half an hour for dinner, but often they were kept working even during these intervals.

The poor little mites were often so exhausted that they lay down on the mill floor and went to sleep, but their taskmasters woke them with cruel blows and drove them to the machines again.

We are told that when the pauper children arrived in the factory districts they were deposited in dark cellars, where the merchant dealing in them brought his customers to see them. The most heartrending cruelties were practised upon the friendless little creatures. They were flogged and fettered and tortured with the most exquisite refinement of cruelty. They were in many cases starved to the bone, and they died so fast that it was considered unwise to bury them in local churchyards and cemeteries, so their bodies were taken considerable distances in order that the enormous death rate might not be too noticeable.

One orphan named Robert Blincoe, who was sent from St. Pancras Workhouse at seven to a cotton mill near Nottingham with eighty other children, worked from fourteen to sixteen hours a day and occasionally longer. He was short, and could only reach the machinery by standing on a block, and when he could not keep pace with the machinery we are told that "from morning till night he was continually being beaten, pulled by the hair of his head, kicked and cursed, as were the other children." The poor little fellow declared that it was not in his power to move quicker, but this made no difference.

Soon afterwards he was moved to another factory, and here the tortures practised are too terrible to be recounted in a book of this kind.

It is worth while remembering that while this sort of thing was going on in Christian England, pious men like William Wilberforce and others were agitating energetically on behalf of the negro slaves of the West Indies. These good people held meetings to stimulate public opinion, and many of them in going to their meetings would pass the factories with their lighted windows where the little English slaves were working 16 hours a day.

William Hogarth's painting of the Industrious and Idle apprentices. The industrious youth has a fly-shuttle in his hand

When attempts were made by such men as Lord Shaftesbury, perhaps the greatest Englishman of the nineteenth century, to reduce the hours of labour for children, men like John Bright, who professed to be the friend of the people, fought tooth and nail against any interference with the employers.

It is true that Bright and his friends strove hard to get cheap bread for the people, but cheap bread meant that low wages could be paid in the factories, and as many of these politicians drew their incomes from the factories where the poor little pauper children were being driven to death, they worked hard for the introduction of cheap foreign corn, quite indifferent as to what would happen to English agriculture.

John Bright is often called "the tribune of the people," but he was no friend of the people. He showed by his attitude to factory legislation that he had no real care for them, and in every possible way opposed Lord Shaftesbury and those who wanted to make conditions in the factories tolerable for the sweated women and children.

It is only right that the true facts about this dreadful period in English history should be recorded, and that it should be known who were the men in public life who fought for and who against the abolition of English slavery.

THE BEAUTIFUL CROSS MADE BY A PEARL OYSTER

Sometimes quite a collection of pearls may be found inside the shell of a single oyster, and the most remarkable collection of this kind ever discovered was that shown in the picture. It consists of nine pearls grouped as a cross about an inch and a half long, and has been given the appropriate name of the Southern Cross. This marvellous shell with its pearls was found in 1874 by an Australian aboriginal, who was collecting shells thrown up on the beach at Raeburn in Western Australia. He sold it for a plug of tobacco, and the recipient sold it for £13 to a man who himself disposed of it for £70. After changing hands several times more it was sold for many thousands of pounds at an auction sale in London. The Southern Cross is here shown slightly larger than natural size.

A LIGHTHOUSE AS FIRM AS A ROCK

Without machinery it would, of course, be impossible to build the modern type of granite lighthouse on a wind and wave swept rock. A lighthouse like the Eddystone is as solid and strong as the rock itself, and it needs to be, for the power of the waves is immense. At one lighthouse fourteen stones of two tons each cemented together 37 feet above high water were washed away by the angry waves. Here we read how a lighthouse can be made to resist such waves

The landsman has little idea of the power of the waves and how strongly a wind and wave swept lighthouse must be built if it is to stand as firm as a rock.

It was John Smeaton, the builder of the third Eddystone lighthouse, who showed the way to build a stone lighthouse on a rock, that could defy the most powerful winds and waves that beat against it.

In the first place he determined to build it of granite and not of wood like previous lighthouses. Then he decided to follow the design of a tree trunk and make the lighthouse a gradually tapering tower with circular walls free of projections.

Finally he decided to dovetail the stones together and to dovetail the lower layers into the solid rock. In this way the lighthouse really became a part of the Eddystone rock, and how triumphantly the genius of Smeaton was vindicated was proved by the fact that his lighthouse stood for nearly a century and a quarter.

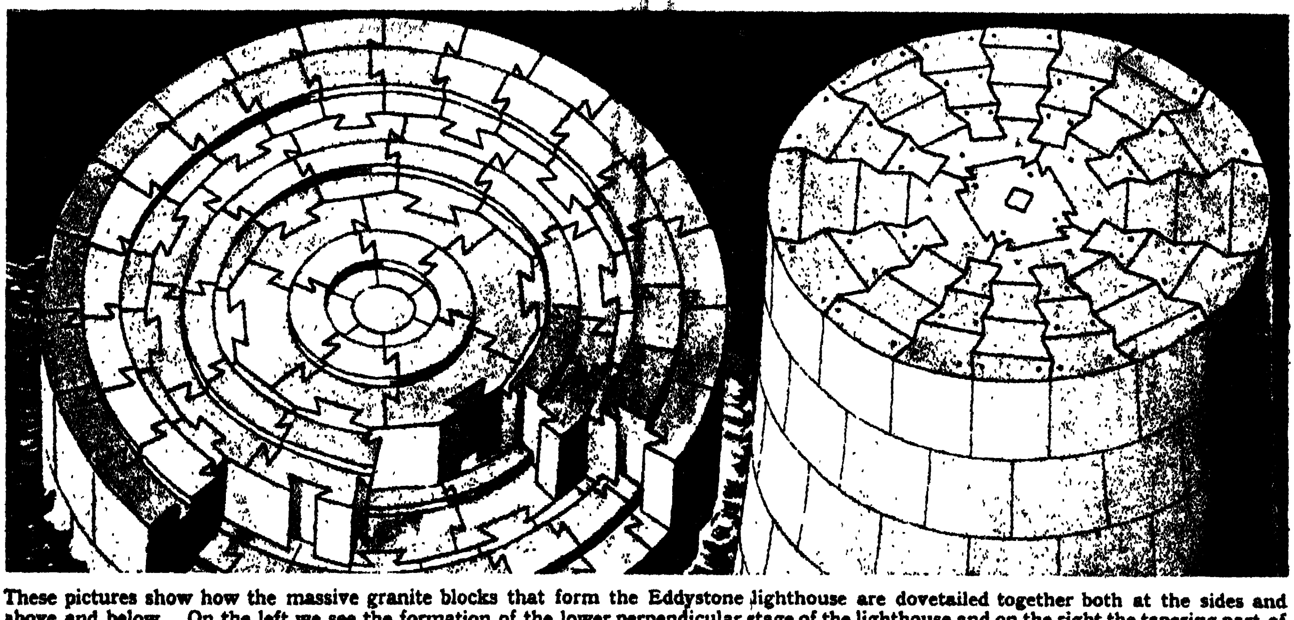
Then it was found that the onslaught of the waves had jarred the joints in the stones and undermined the very rock on which the lighthouse stood.

A model of one of the two-ton blocks of granite which are dovetailed together to form the present Eddystone lighthouse. The metal shackle and expansion wedge are for lowering the block into position.

It was, therefore, decided to build another lighthouse, bigger and more powerful, on another part of the terrible and dangerous rock. It was a tremendous task, for the part of the rock on which this fourth Eddystone lighthouse stands is beneath the level of low tide and the lighthouse itself is nearly twice the height of Smeaton's.

This magnificent lighthouse took nearly four years to build. It is made of granite and the base is 44 feet in diameter and for 44 feet from its base is perpendicular. Then it begins to taper slightly, but for another 25 feet it is solid except for a water tank.

The great massive slabs of granite are dovetailed together both laterally and vertically, that is, projections on each stone fit into the next stones on either side and to the next stones above and below, and could not be displaced without breaking. The lighthouse is practically one piece.



These pictures show how the massive granite blocks that form the Eddystone lighthouse are dovetailed together both at the sides and above and below. On the left we see the formation of the lower perpendicular stage of the lighthouse and on the right the tapering part of the tower. There are in the lighthouse, altogether, 2,171 stones weighing 4,668 tons. In Smeaton's lighthouse the stones were half the size

WHAT THE SOUTHERN CROSS IS

We often see in books of travel and novels dealing with life in the southern hemisphere references to the Southern Cross, and books have been published with such titles as "Under the Southern Cross."

It is curious how many people who know this expression and understand that it has something to do with the southern hemisphere have no real idea what the Southern Cross is.

It is, of course, a constellation or group of stars of the southern heavens, and is visible only to those who live or travel in southern latitudes. The Southern Cross is a very small constellation, but it is noticeable because it has four bright stars in the form of a cross, and it is perhaps understandable that the old travellers showed a superstitious reverence for this group of stars which appeared to them to be a symbol of their faith.

A Useful Guide

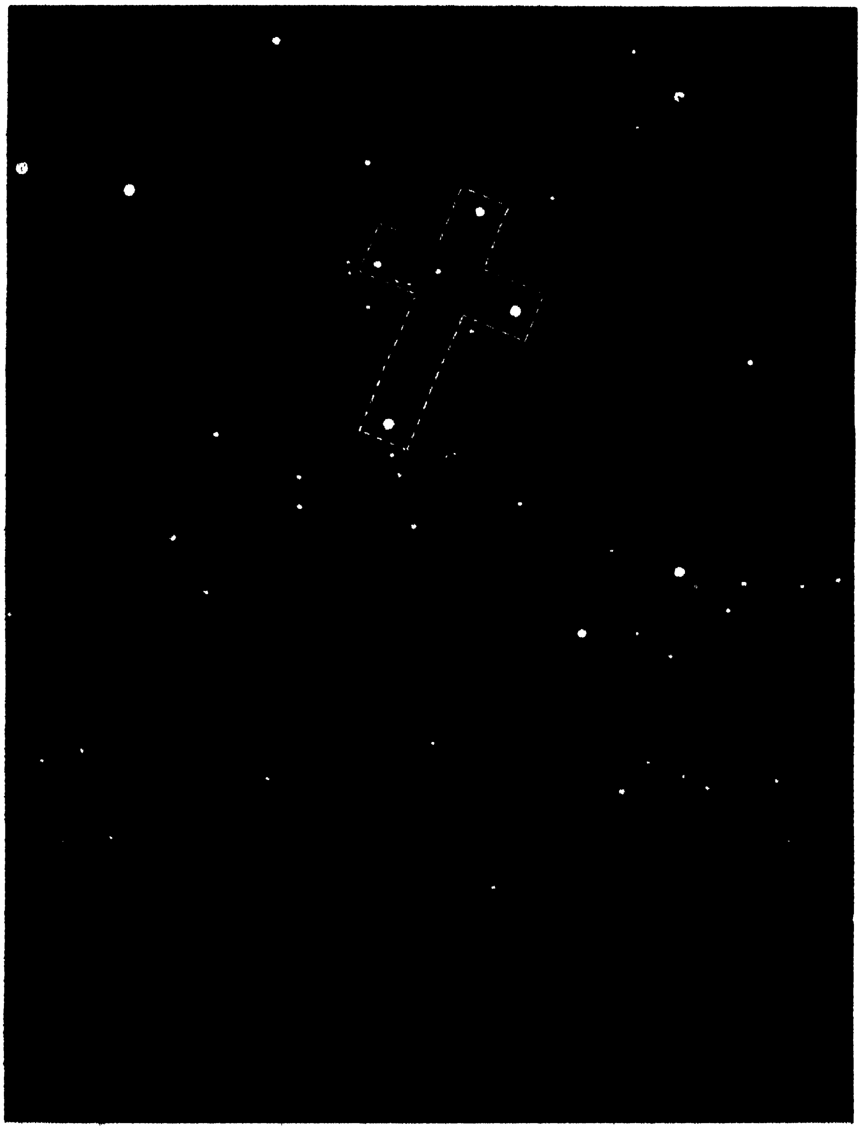
The Southern Cross is to those who live or travel south of the Equator what the Plough is to those in the northern hemisphere. It is an easily recognised group of stars, from which it is possible to find other constellations of the southern heavens.

The upper and lower stars of the Southern Cross are always on the meridian at about the same time, and they serve, like the pointers in the Great Bear, to indicate roughly the direction of the south pole of the heavens. But, unfortunately, there is not any definite star in the south like our Pole Star in the north which marks the celestial pole.

About five thousand years ago the Southern Cross was visible from the Earth's northern hemisphere, and it could be seen even from the British Isles. Now it cannot be seen at all north of the Equator. It is, however, gradually receding from the south pole of the heavens, and the day will probably come again, though at some very distant date, when it will reappear above the horizon of Europe.

The general appearance of the four bright stars of this constellation, as visible to the naked eye, can be seen in the picture on this page. A photograph of the Southern Cross, taken with a large telescope, is given on page 241, and in that photograph we see the curious black patch in the heavens which is known as the "Coal Sack."

At one time this was supposed to be a "hole," as it were, in the heavens, a vast tunnel in which there were no stars. Other such black patches have since been discovered, and it is now believed that these are not empty spaces, but dark nebulous matter which blots out the stars behind them.



The Constellation of the Southern Cross with its four bright stars in the form of a cross as seen from New South Wales. For clearness the stars are here outlined as a cross

The Southern Cross is sometimes called the Clock of the Night, because from particular places in the southern hemisphere it is never seen to set. It is always visible from the Cape of Good Hope and Australia, just as the Great Bear is always visible from the latitude of London.

Many famous travellers of earlier days have noted the Southern Cross. Alexander von Humboldt states that one experiences an indescribable sensation when in passing from one hemisphere to the other, he sees the stars with which he has been familiar from infancy gradually approach the horizon and disappear.

A Sign of Faith

"We saw distinctly," he says, "for the first time the Cross of the South. It was strongly inclined, and appeared from time to time between the clouds. The pleasure felt on discovering the Southern Cross was warmly shared by such of the crew as had lived in the Colonies. Among the Portuguese and the Spaniards peculiar motives seemed to increase this feeling; a religious sentiment attaches them to a constellation the form of which recalls the sign of the Faith planted by their ancestors in the deserts of the New World."

Even so far back as the beginning of the 14th century, the Italian poet, Dante, seems to have had some knowledge of the existence of this group of stars, for in his Divine Comedy we find the following passage:

> "To the right hand I turned, and fixed my mind
> On the other pole attentive, where I saw
> Four stars ne'er seen before, save by the ken
> Of our first parents. Heaven of their rays
> Seemed joyous. O thou northern site! bereft
> Indeed, and widowed since of these deprived."

If this was only a poetic fancy, it was a strikingly accurate shot at the truth.

THE MYSTERY OF THE BEAN FAMILY

No novel is more romantic than some of the wonderful stories of nature that men of science have discovered, and one of the most surprising of these is the tale of the bean and pea family and how its plants enrich the soil with nitrates so that other plants can grow and thrive. It is the story of a strange partnership between plants and animals and here in these pages we read about it

There is no doubt that during the past hundred years more scientific discoveries have been made than in all the scores of preceding centuries in man's history. Yet we find the germ of many of these discoveries far back in ancient times. The great mystery of the bean and pea family, which has only been solved in the last half century, is a striking example of this, and the story is truly one of the romances of plant life.

Of course, we all know that peas, beans and lentils, which are spoken of generally as the pulses, are exceedingly valuable as human foods, and that similarly the clovers and the vetches, which belong to the same family, are splendid foods for cattle and sheep.

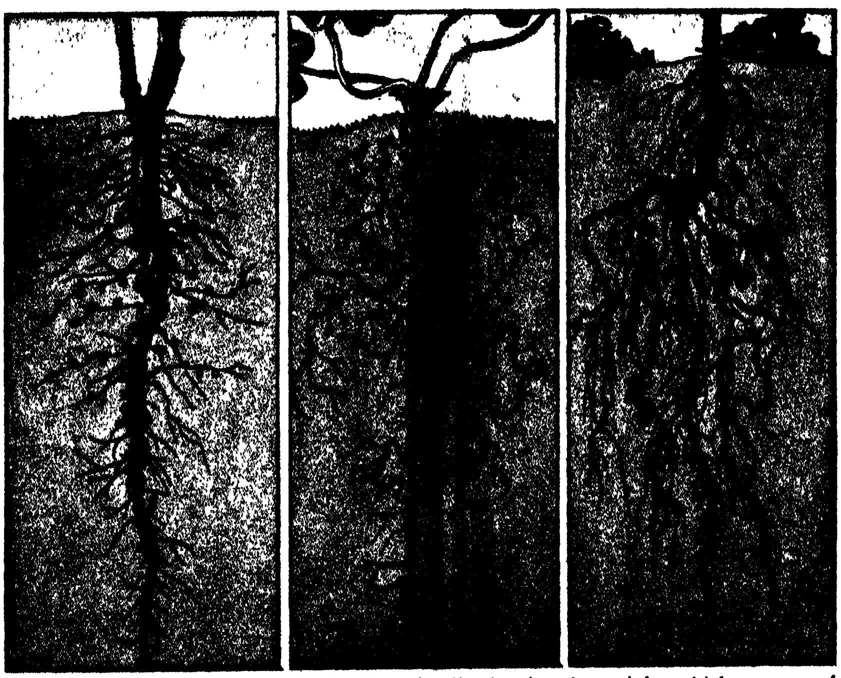
Seeds in Pods

This family of plants, which men of science call the leguminous family, is so named from the Latin word legumen, which means "that which may be gathered by hand without cutting." It is a reference to the fact that all the members of the family produce their seeds in a pod, which can be pulled from the plant without difficulty.

The most familiar members of the family are, of course, the garden pea, and the scarlet runner and other beans. These, with lentils, have been described as "the poor man's beef," because their nutritive value is so high, owing to the large proportion of protein which they contain. About one and a third pounds of pea-flour a day would supply all the protein required by an active man, but as the pulses are not so rich in carbohydrates, that is, starch and sugar which serve as fuel to the body, they are not suitable for an exclusive diet.

Owing to their high proportion of protein, however, they form excellent tissue builders, and Dr. Robert Hutchison, the great food expert, says, "Their use is strongly to be recommended, and it is a pity that they are not more largely taken advantage of by those to whom economy is of importance, for unquestionably the pulses are among the cheapest of foods, and a given sum will yield more protein if invested in them than in any other way."

But there is another way in which the leguminous plants are of the utmost value, and this has only been discovered fully in recent years. It has been known from the very earliest days of agriculture that the soil could be made more fertile by growing in it crops of leguminous plants. Farmers discovered this and, through the centuries, acted upon their knowledge, although they did not understand in what way the leguminous plants helped the soil. Scientists were no wiser, but they determined to find out the facts, and after long and patient investigations they did so.



The roots of three plants of the leguminous family showing the nodules which are caused by bacteria in the soil, which take free nitrogen from the air and from it form nitrates on which plants can feed. On the left is the horsebean, in the centre the red clover, and on the right the soy or soya bean

All plants, if they are to grow and be healthy, must have plenty of protein, and this is made up largely of nitrogen gas combined with other elements. Without nitrogen there can be no life, and if a plant—and the same thing applies to animal life—is deprived of food containing nitrogen, it sickens and dies.

Now there are abundant supplies of nitrogen in the atmosphere—indeed about four-fifths of the air consists of nitrogen. One scientist, Mr. Geoffrey Martin, estimates the quantity at 3,980 billion tons. He says that every square yard of land has about seven tons of nitrogen lying over it.

Getting Nitrogen

Unfortunately, neither animals nor plants can absorb nitrogen in the free state; they can only take it into their systems from certain nitrogenous compounds. We human beings get our nitrogen in the form of animal and vegetable food. Every meal we eat represents so much nitrogen. The animals which we eat get their nitrogen from the grass and plants that form their food, and the plants in turn obtain practically all their nitrogen from the soil in which they grow. We are thus, plants and animals alike, all dependent upon the soil for the nitrogen without which we cannot live or thrive.

If neither animals nor plants can absorb the free nitrogen of the air which is all around them, it might seem that there must be a complete deadlock; but as already explained, nitrogen can be taken in the form of certain compounds of which it forms one of the elements, and this is true not only of animals but of plants also. The plants as they grow extract supplies of nitrogen from compounds in the soil

but, of course, as they do this the soil gets poorer and poorer in nitrogen until at last, if nothing is done to replenish the earth, the soil becomes barren and useless.

There are large tracts of land in Sicily and North Africa, and elsewhere, which were once very rich corn-producing regions, but which are now practically sterile because their soil has little or no nitrogen and so plants cannot grow there

Putting the Nitrogen Back

The same thing would happen on all farms, but man has learned to replace the nitrogen which is taken out of the soil by the plants, by manuring the ground The manures or fertilisers which we mix with the soil, have in them compounds containing nitrogen, and the roots of plants have the power of extracting from these substances the nitrogen which they need to build themselves up.

In the old days, when men were few, and horses and cattle were many, there was an adequate supply of natural manure from these animals to feed the soil, but now when the world's population is so great and larger supplies of food are needed for mankind, there is not sufficient natural manure to meet the needs of the farmer, especially as horses are getting fewer and fewer.

The deficiency has been made up very largely by putting mineral manures on the land in the form of nitrates, large deposits of which are found in Chile and elsewhere. But the supply of nitrates must eventually be exhausted, and man will then have no alternative but to make his own nitrates in some way, using the nitrogen of the air for the purpose. He has already made a start in this line, and will no doubt succeed in producing larger and larger crops from the soil.

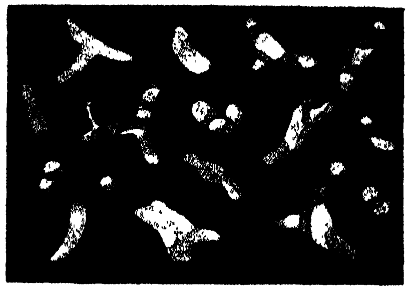
Scientists Puzzled by a Plant

Now let us come back to the leguminous plants. It would take too long to tell the whole story of how men of science discovered the way in which these plants enrich the soil and make it more fertile.

After long and patient investigation it has been found that the leguminous plants alone of the many families of plants that grow have the power of taking nitrogen from the air and using it for the building up of their bodies. Peas and beans and other relatives of theirs do not absorb this nitrogen by means of their stems and leaves; it is the roots that take up the nitrogen from air mixed with the soil. As we know, the particles of the soil lie more or less loosely together, and the spaces in between are filled with air.

At first the scientists could not understand why it was that these particular plants were able to do what other plants could not do. Slowly and surely, however, they pieced the story together. They noticed that the roots of leguminous plants always had little swellings or nodules on their roots. They examined these swellings and found that they contained bacteria, or lowly plant forms that need a microscope before they can be seen.

They eventually came to the conclusion that leguminous plants, by means of these bacteria found in their roots, had the power of obtaining

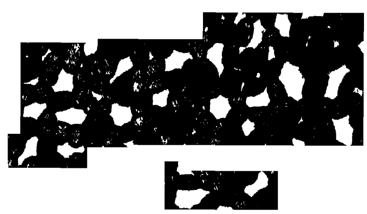


Bacteria (magnified) which fix the nitrogen of the air and make it available for plant food

nitrogen from the air and so were able to get the necessary food to build up their bodies

One Ounce of Teeming Life

Up to that time little or nothing had been known about bacteria in the soil, but when scientists began to examine the soil they found, to their astonishment, that so far from it being a dull, lifeless mass of matter, it teemed with living creatures. In an ounce of rich loam soil, for example, there may be as many as 150 million bacteria, and in



Grains of soil, magnified, showing the spaces filled with air among them. It is from this air in the soil that the bacteria take the nitrogen needed for their life

some soil, such as that which has become polluted with sewage, or watered with manure, the number may be as high as 3,000 million in every ounce.

Penetrating the Roots

It was found that the particular kind of bacteria in the nodules of the leguminous roots are not peculiar to them, but that these also live in the soil. For some reason or other, however, they make their way through the thin wall of the root-hairs of the leguminous plants, and then multiply so rapidly that they infect the tissues of the root as a whole and lead to the formation of the swellings or nodules.

Many millions of these bacteria are found in the root of a single plant. They at once begin using the sugar which the plant has built up for its nourishment, and they take up from the air circulating in the spaces of the root, free nitrogen and combine it with other elements in their tissues. In this respect they are able to beat the very cleverest human chemists.

Making up for Lost Sugar

Of course, when these bacteria use the sugar in the roots, the plant suffers loss, but it soon makes up for this by taking from the bacteria the nitrogen which they have combined with other substances in their bodies. Thus the leguminous plants become rich in nitrogen and thrive in the soil.

But how is it that the soil is enriched for the next crop by the growing of beans or peas or clover? Well, when these plants die or are gathered, some surviving bacteria remain in the soil and re-infect it, while the roots of the gathered crop of leguminous plants remaining in the soil, supply nitrates which have been built up in the swellings. The soil is thus fertilised as though it had been manured with artificial nitrate fertiliser.

The knowledge thus gained is exceedingly valuable, and the growing of crops in rotation is put on a scientific basis. The farmer on all his arable land grows, in a certain succession, crops of leguminous plants, not only for their own sake but in order to enrich the soil for his next crop.

Of course, there are very many members of the leguminous family, in addition to the peas, beans, lentils and clovers, which are so familiar to us. One botanist tells us that the family has no fewer than 10,782 species.

A Very Important Family

No family is of greater agricultural importance, unless perhaps it be the grass family, which includes wheat, oats, barley and so on. The protein in which the leguminous plants are so rich is found in all parts of the plant, and not in the seeds alone

The seeds of the leguminous plants are noted for their great length of life. It is said that some have retained their vitality for a couple of centuries. Where these plants grow in dry climates a large percentage of the seeds have hard coverings which prevent the seeds drying up.

The interesting thing about the discovery which has been described is that plants like peas, beans, lentils, clover, and their relations really live in a kind of friendly partnership with the bacteria, the leguminous plants supplying food to the bacteria, while the bacteria, in their turn, take nitrogen from the air, combine it with other elements to form nitrates, and supply food to their hosts. They are really very generous, for in addition they leave a store of nitrates in the soil for the plants of another season.

THE WONDERFUL CYCLE OF NITROGEN IN THE SOIL

All plants and animals need nitrogen if they are to grow and thrive, and there is plenty of nitrogen in the air for their use. But neither animals nor the majority of plants can use the free nitrogen of the air. It must be in the form of a compound. What is to be done ? Well, there is a wonderful romance of nitrogen which is shown in these pictures. Certain bacteria in the earth can take the nitrogen from the air, which is mixed up with the grains of soil, and, entering the roots of leguminous plants like beans and peas and clovers, combine it with substances in those roots and form nitrates. The leguminous plants then enrich the soil with these nitrates, and when some other crop is grown on the same soil it finds nitrate food and thrives. Animals then eat the crops, and human beings eat both animals and plant food, getting nitrogen in compound and digestible form from them. The refuse and remains of animals in the soil cause bacteria to multiply there, and so what has been called the nitrogen cycle goes on continuously to the advantage of all

THE IMPORTANCE OF SITTING PROPERLY

We shall probably notice as we go about that many people, both old and young, are round shouldered or slouching in their gait. Of course, we cannot all be beautiful or tall, but we can all within reasonable limits be upright.

Growth is a natural process, and, as the Bible says, none of us by taking thought can add one cubit to his stature We can, however, by thought become well formed, and it largely depends upon ourselves. If we are careless in our walking and standing and sitting we shall become round-shouldered and bent in the back, and backs to the wall, stand as upright as we can, with the lower part of the body and the shoulders and the back of the head just touching the wall. If we can do this with comfort and ease and feel that we are standing naturally, then we are growing well, and our body is upright as it should be.

Then for a sitting test let us place a stool, such as a bathroom stool, of a suitable height, against a vertical wall, and sit upon it with the lower part of our body touching the wall. Then let us lean back till our head also touches the wall, and if we are growing well our shoulders also will touch the wall.

This picture is a realistic illustration of the importance of sitting and standing correctly. The skeleton, which is the framework of the body, becomes permanently deformed by wrong attitudes, and if only we could see our skeletons we should be more careful. The figure on the left shows the skeleton of a person who has become round-shouldered and developed defects of the backbone by wrong sitting. In the centre the foremost figure is sitting at the piano in the right position, on a seat of the correct height. The far figure is in a wrong position owing to a seat that is too high. If persisted in such a method of sitting will deform the spine. The figure on the right has become deformed through the constant practice of lifting loads that are too heavy, a very dangerous and unwise thing to do

these things generally mean ill-health. If we do not walk upright we cannot breathe properly, and if we sit huddled up we shall do harm to other organs of our bodies.

Man is an upright animal, and this physical erectness he owes to the fact that he has an upright framework, the bony skeleton, and muscles which assist in keeping the body in the right position.

There are two simple tests by which we can know whether we are helping our bodies to grow correctly. First of all, with regard to the standing position. Let us go to the wall and, placing our heels together against it with our

Perhaps when we carry out these tests we shall find that while we can touch the wall at the points named, our position seems very strained and unnatural. In that case it is pretty certain that we are not carrying ourselves as we should do and helping our own growth along healthy lines. To get right we should carry out certain exercises. A doctor or a gymnastics master or mistress will tell us what these should be.

One very important thing for boys and girls to remember is that when they are sitting reading or writing they should keep their backs as upright as possible. In the old days children were taught to place their left arm forward on the table or desk and to write with the right wrist resting on the desk. The result was that the left shoulder was raised above the right, and as the habit was constantly practised through the growing years when the bony skeleton was hardening, the child grew up with the right shoulder permanently lower than the left. Now in school boys and girls are taught to write with both elbows equally placed on the table or desk.

In such operations as playing the piano, reading a book, or listening to a speaker, we should be sure to keep our spines upright. Otherwise, if we are always bending forward they will become permanently bent, and our chests also will become flat, so that we cannot use our lungs to the full extent.

Of course, some people, owing to the nature of their occupation, find it difficult to keep from deforming their bodies. Men who are constantly carrying very heavy loads on their backs often become bent or round-shouldered, and this shows how important it is that growing boys and girls should never carry weights that are too heavy for them. Let us do our best if we have sound and healthy bodies to grow up with erect and good figures.

THE LIFE-STORY OF THE CUCKOO-PINT

The wild arum or cuckoo-pint is one of those British plants which depend upon insects for the fertilisation of their seed-bearing parts, and here we see its life-story. A seed which has fallen to the ground sprouts and grows into a plant, which bears a bud that develops into the well-known spathe or sheathing-leaf enclosing a spadix or fleshy spike. In these pictures the lower part of the spathe is cut away and we see how midges, covered with pollen from an older plant, pass through a palisade of spikes and, being unable to return, fly about and shake the pollen on to the stigma or female parts, fertilising them. These develop into red berries known as "lords and ladies," which contain seeds. The spathe withers and the midges then escape to fertilise other arums. The berries fall to the ground and later sprout into new plants and thus the species is carried on from generation to generation

THE DIGNIFIED ADJUTANT BIRD

No big bird looks so dignified and solemn as it walks about with slow and stately tread as the adjutant or marabou stork We may see it when we next visit the London Zoo It is very common in north-eastern India, especially in Bengal, where it spends the summer, arriving in April or May, and flying away in October to Burma and Malaya, where it breeds.

It builds its nest, which consists of little more than a rough pile of sticks, on some rocky cliff or lofty tree, and there lays two white eggs. But it is during its annual visit to Bengal that it is best known It struts about solemnly and pompously like a dignified military staff-officer, hence its popular name of adjutant.

It is a great scavenger and is regarded as so important in this capacity that it is rigidly protected by law. How necessary this protection is can be understood when we remember that at one time large numbers were slaughtered for their undertail covert feathers, which were much sought after in Europe and America for the making of ladies' wraps and the trimming of hats and dresses. They are known as marabou feathers. Marabou is from an Arab word meaning a hermit, and the name was given to the bird because of its fancied resemblance to a hermit.

The adjutant devours any offal that may be lying about among the refuse heaps in the streets and lurks about the slaughter-houses and burning grounds of the Hindus. Any dead dog or cat that may be found is eaten with relish, and even larger carcasses.

It can be understood how valuable such a bird must be in a hot country like India where the natives are not very particular about the disposal of their refuse. At the same time the adjutant will readily devour a fish or a frog, or a small bird.

Now that they are strictly protected by law the adjutants become quite tame and walk familiarly about the streets of the Indian towns among the people in a very amusing way.

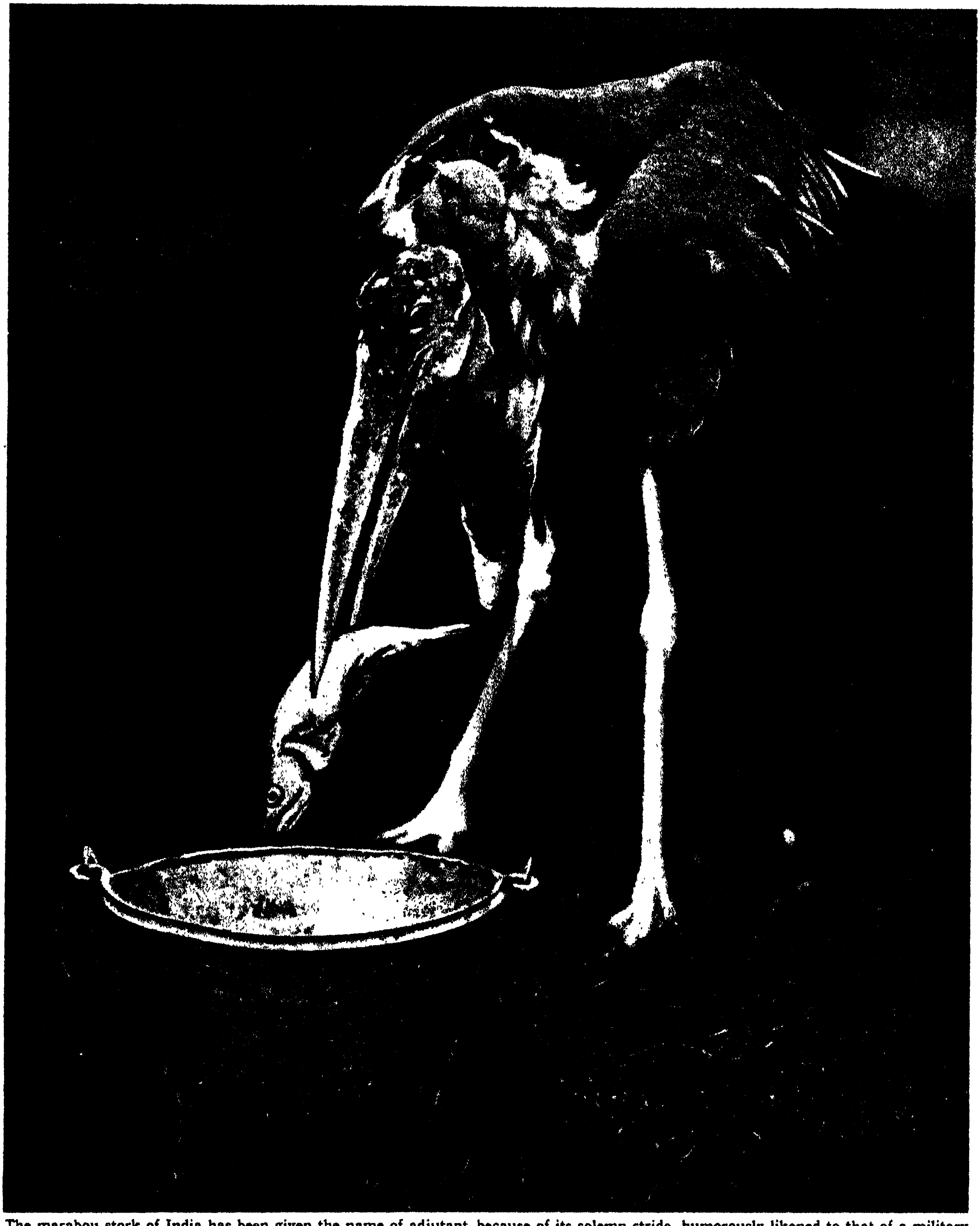
The adjutant has a curious pouch hanging down the front of its throat but the use of it is not yet understood by men of science. An African species of marabou also has this pouch and on account of its curious appearance the Arabs call the bird " the father of the leather bottle."

Adjutants hardly look like birds that can fly high or swiftly, yet although their flight is heavy and flapping, it is powerful and they soar to great heights and then come down to join the vultures at a feast of carrion, pecking their way among these birds and getting the lion's share of the meal. When they are annoyed they can certainly give a very vigorous peck.

Adjutants are generally seen in large flocks, especially in the hills where they nest. In January the parents are to be seen feeding their young birds high up on the pinnacles of almost inaccessible rocks. In the neighbourhood of towns, however, adjutants stalk about alone, or stand with wings outspread drying their plumage.

The queer and very solemn attitude assumed by the adjutant when it is resting on the ground after a meal

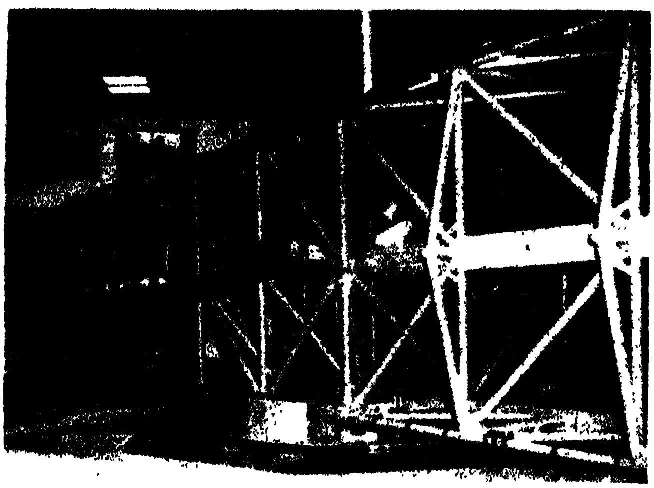
THE ADJUTANT HELPS HIMSELF TO A MEAL

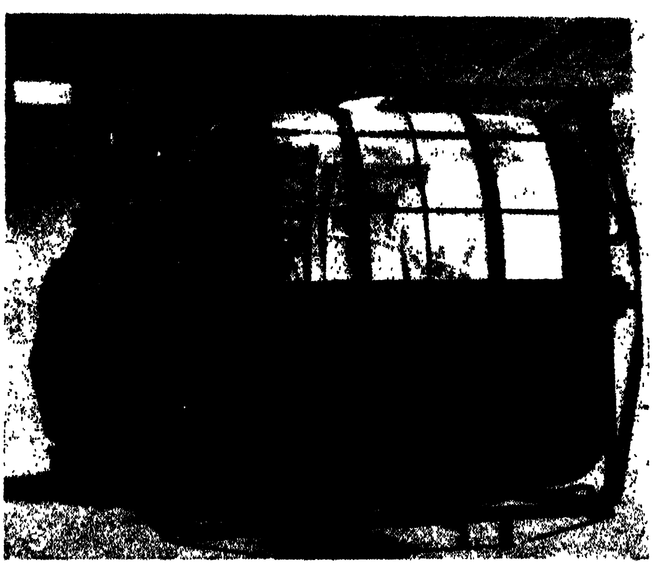


The marabou stork of India has been given the name of adjutant, because of its solemn stride, humorously likened to that of a military officer on parade. It is the largest and ugliest member of the stork family, and with its rough plumage and naked neck always looks rather untidy. It is only a summer visitor to India, arriving in that country in April or May, remaining through the rainy season, and leaving in October. The rest of the time it spends in Burma or Malaya, where it nests. Because of its great value as a scavenger the adjutant is protected by law in Calcutta and other Indian cities. It will eat anything dead from a large animal to a cat or fish

MERRY-GO-ROUND FOR AVIATION'S G-MEN

High-speed flying, particularly if the aircraft suddenly accelerates or changes direction, plays odd tricks with gravity which can have serious effects on the pilot. Thus excessive acceleration increases the influence of gravity on the pilot's body and can drain the blood from his brain, so causing the state of unconsciousness called "black-out." The amount of extra gravity force which a man can stand is measured in Gs. As it would be dangerous to experiment in the air to find out how many Gs would affect a pilot, the machine illustrated here is used to create different gravity conditions on the ground. The "pilot" is seated in a cabin (1 and 4) which is mounted on a long arm (2) and whirled round at high speed by an electric motor. Attached to the pilot are various instruments to register what is happening to him. The readings from the instruments are then recorded on a strip of paper passing through the machine shown in 5, and examined by medical experts. The outside of the cabin and the manner in which it is mounted on the arm are shown in 3





MODERN WONDERS OF ILLUMINATION

One of the greatest blessings that modern invention has brought to the world is improved lighting. In these days of well-lighted streets and houses, of powerful headlights on motor-cars, and electric torches and hand-lamps it is difficult for us to realise the horror of night and darkness which people had in the old days. Here we read something about old and new methods of lighting

The night had a great horror for the people of olden times, who feared darkness, with its lurking dangers, as they feared few other things

Literature is full of references to this In the Bible, for instance, one of the most terrifying plagues of Egypt was "a thick darkness in all the land" which lasted for three days, and the punishment threatened to the wicked was that they should be "driven from light into darkness," and experience "the blackness of darkness for ever." The righteous, on the other hand, were to have their darkness turned into light, so that even the night should be light.

It has been well said that when the streets of London were first lighted with gas in the early part of the nineteenth century, the new lighting did more for morality and the reduction of crime than all the preachers and guardians of the law, so true is it that "everyone that doeth evil hateth the light, neither cometh to the light lest his deeds should be discovered."

How poor were the attempts to light the streets before the advent of gas! In the City of London a law was made that everyone should put a candle out over his door at night in a lantern The candles were put up, but often they burned out or were blown out by the wind. Such feeble lights only served to emphasise the darkness

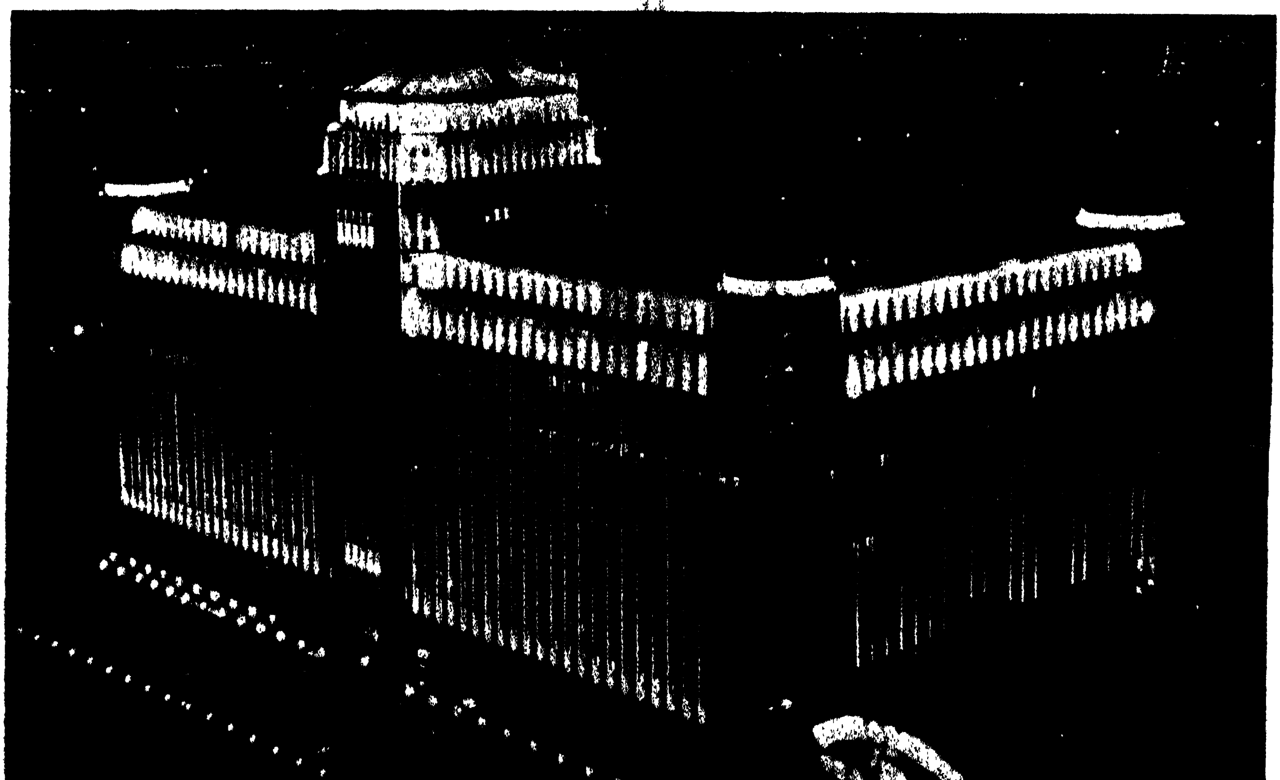
When the authorities lighted the streets with oil-lamps it was a great step in the right direction, but gas was really the beginning of modern lighting Then came electricity, and the gas mantle, with the cheapening of production and now the streets of a great city are almost as light at night as they are in the day-time.

In the home, too, amazing advances have been made in lighting. Think of the old days when, before a light could be obtained on a dark winter morning, the tinder had to be lighted by a spark struck with the steel and flint. If the weather was damp and the tinder was not perfectly dry it might take half an hour or more to get a light. Poor people could not afford candles and had only rushlights, that is a rush dipped in tallow, to light their homes.

Then came oil lamps, followed later by gas, incandescent mantles and electric light Now with inverted bowls and indirect lighting, the illumination of the home is as near perfection as it could be brought.

The latest method of lighting buildings on the grand scale is by tubes of neon and other gases through which an electric current is passed. The gas is at low pressure and the current at low voltage. The neon gas shines with a bright red glow, while other gases give different colours. There is one terminal at each end of the tube and the gas itself carries the current.

The flood-lighting of buildings, too in which the beams of powerful searchlights are directed upon the buildings, gives wonderful effects and has been seen in most of our big cities from time to time on special occasions.



A striking example of modern illumination at the Merchandise Mart at Chicago, where long needles of light outline the building

EXPERIMENTS WITH HOME-MADE TOPS

We can make a number of interesting optical tops which will illustrate important facts about light and vision. The tops consist of stout cardboard discs with a piece of black-lead pencil or pen-holder put through a hole in the centre, the point of the pencil forming a peg on which to spin the top. On the discs we draw or paint the designs which are shown in the pictures at the bottom of this page.

The designs are very clear and distinct as we look at them on the discs when they are still, but when they are spun and they rotate rapidly the result is very different.

The first top design is one in which the seven colours of the spectrum, violet, indigo, blue, green, yellow, orange, red are painted in certain proportions. When the top is spun we no longer see the colours, for they blend and form white.

The next design consists of a five-pointed star painted dark blue. When spun the effect is curious, for the centre is dark blue and the blue becomes lighter and lighter towards the circumference. At the edge the spinning disc appears quite white. Towards the edge, the star rays being narrower, the proportion of blue gets less

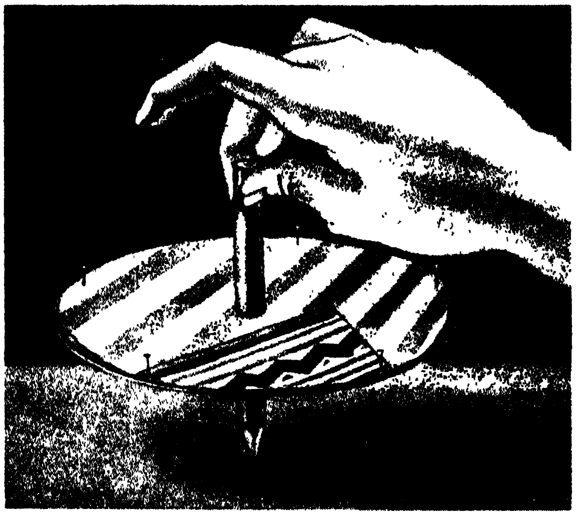
The other four designs can be drawn on the discs in black ink, and it will be interesting to see for ourselves the results when they are spun. In the last one, for instance, where there are four lines with toothed edges on one side we shall find that the rotating disc exhibits a series of rings, those nearest the centre being the darkest.

These are, of course, only a few of the designs with which we can experiment. We can make up for ourselves many others and see what happens when we spin the discs.

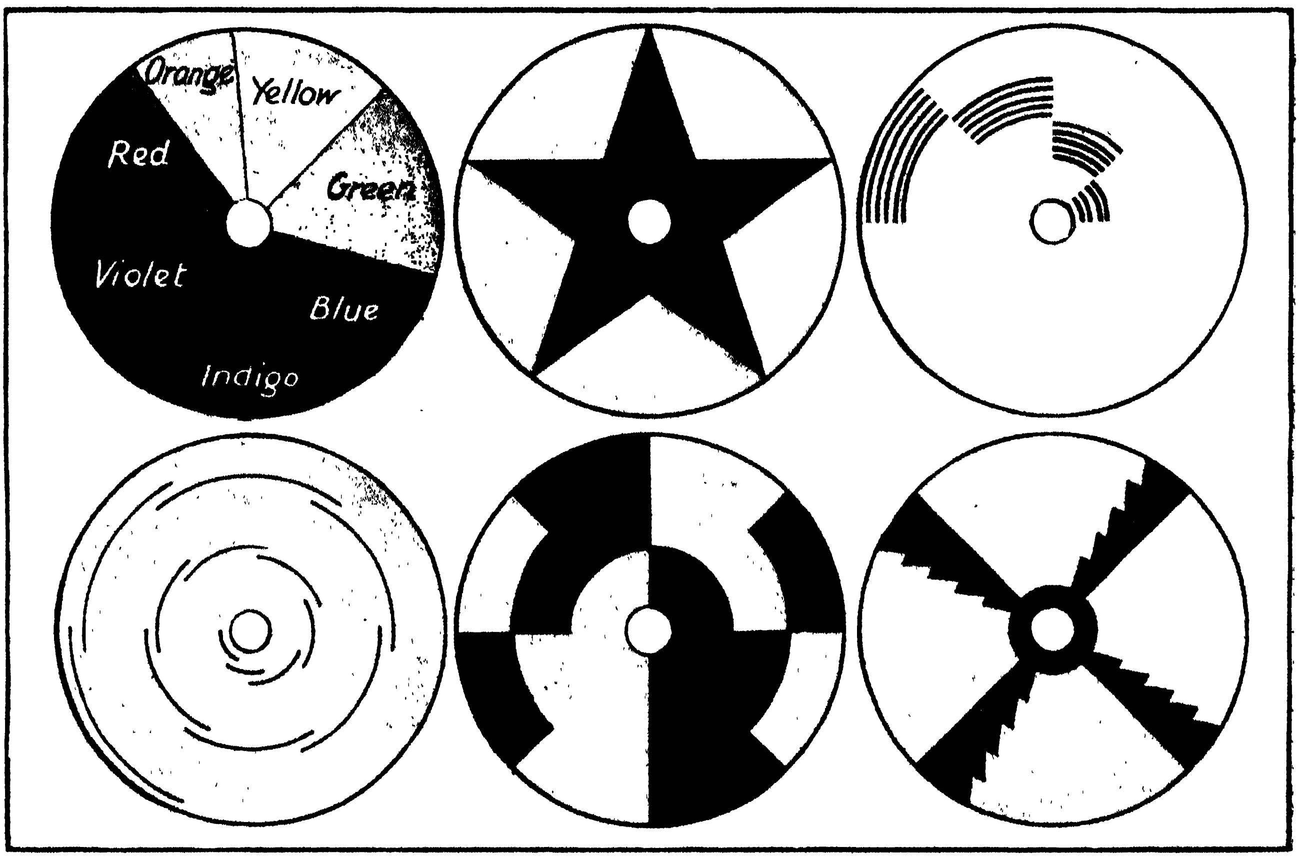
Girls will find a home-made top of this kind very useful for matching the colours of materials. If, for instance, the colours of two materials should be alike, while the pattern or design is different, it is not always easy to decide whether the colours do really match. We can, however, do this with a top. We cover the disc with one material and fasten a small piece of the other on the edge. Then when the top spins we shall soon see whether there is any difference in the tints. It will be far more conspicuous when spinning than when still.

The effects of these tops are due to the persistence of vision, that is the images formed on the retina of various parts of a design as it rotates blend as do the various pictures of a film as it is run through the projector at the cinema.

If it were not for this persistence of vision we should be unable to see moving pictures on the screen. If our eyes were quick enough we should detect not what appears to be a continuous moving picture but a series of pictures all slightly different from one another

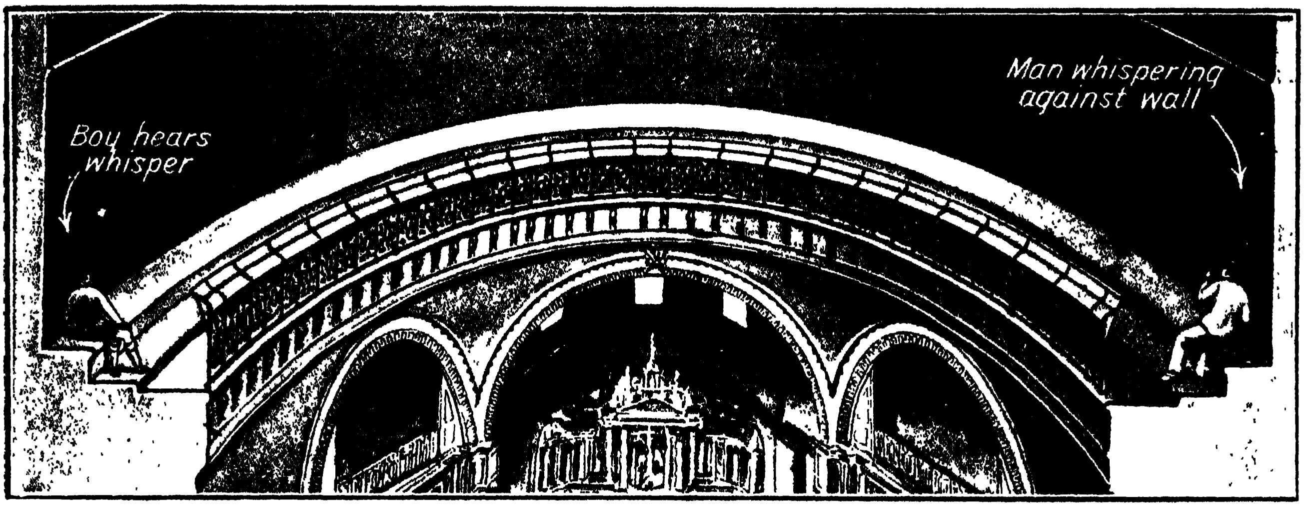


Matching a colour by means of a top

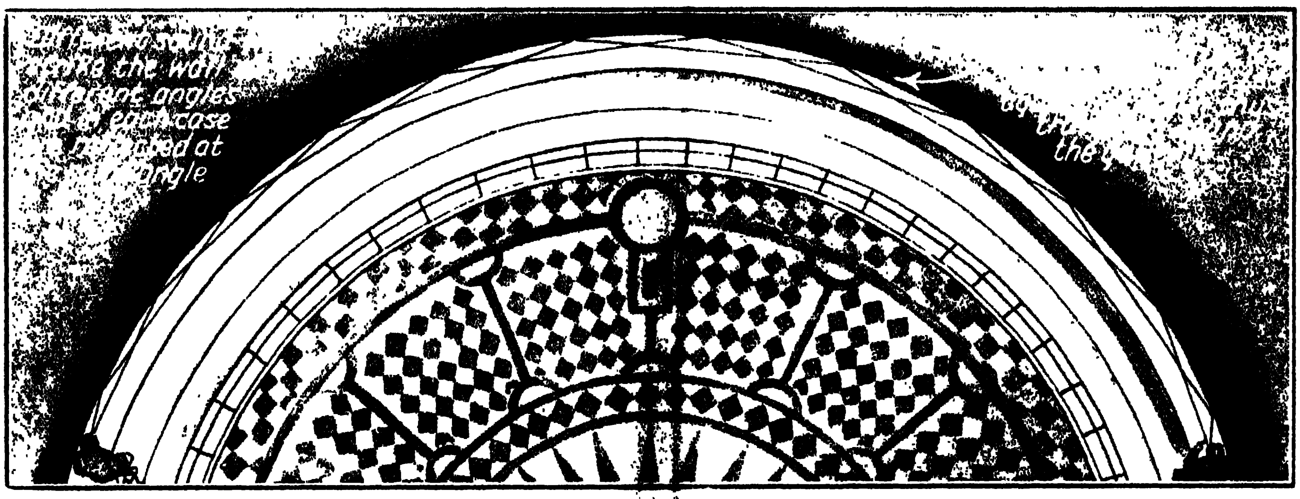


A number of designs for home-made tops which will help us to understand the principle of the persistence of vision

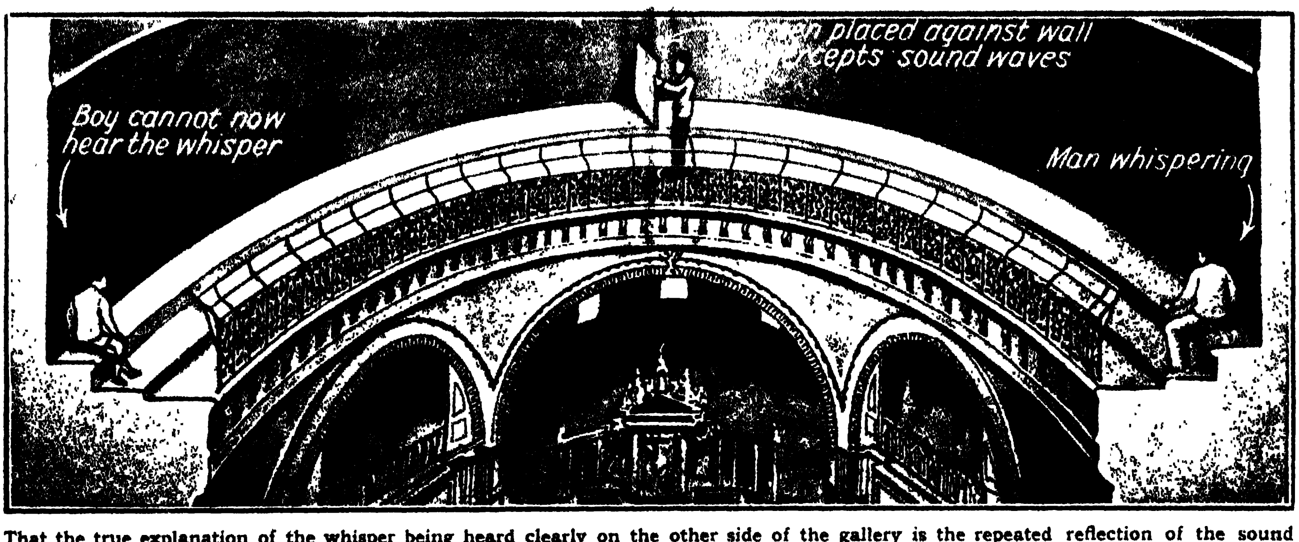
WHY WE CAN HEAR A WHISPER IN ST. PAUL'S



One of the most interesting parts of St. Paul's Cathedral is the Whispering Gallery, which is 108 feet in diameter or nearly 340 feet in circumference. It is the best point from which to see the paintings on the dome, but what makes it so very interesting is the fact that if a person whispers near the wall on one side of the gallery anyone with his ear against the wall on the other side can hear what is said

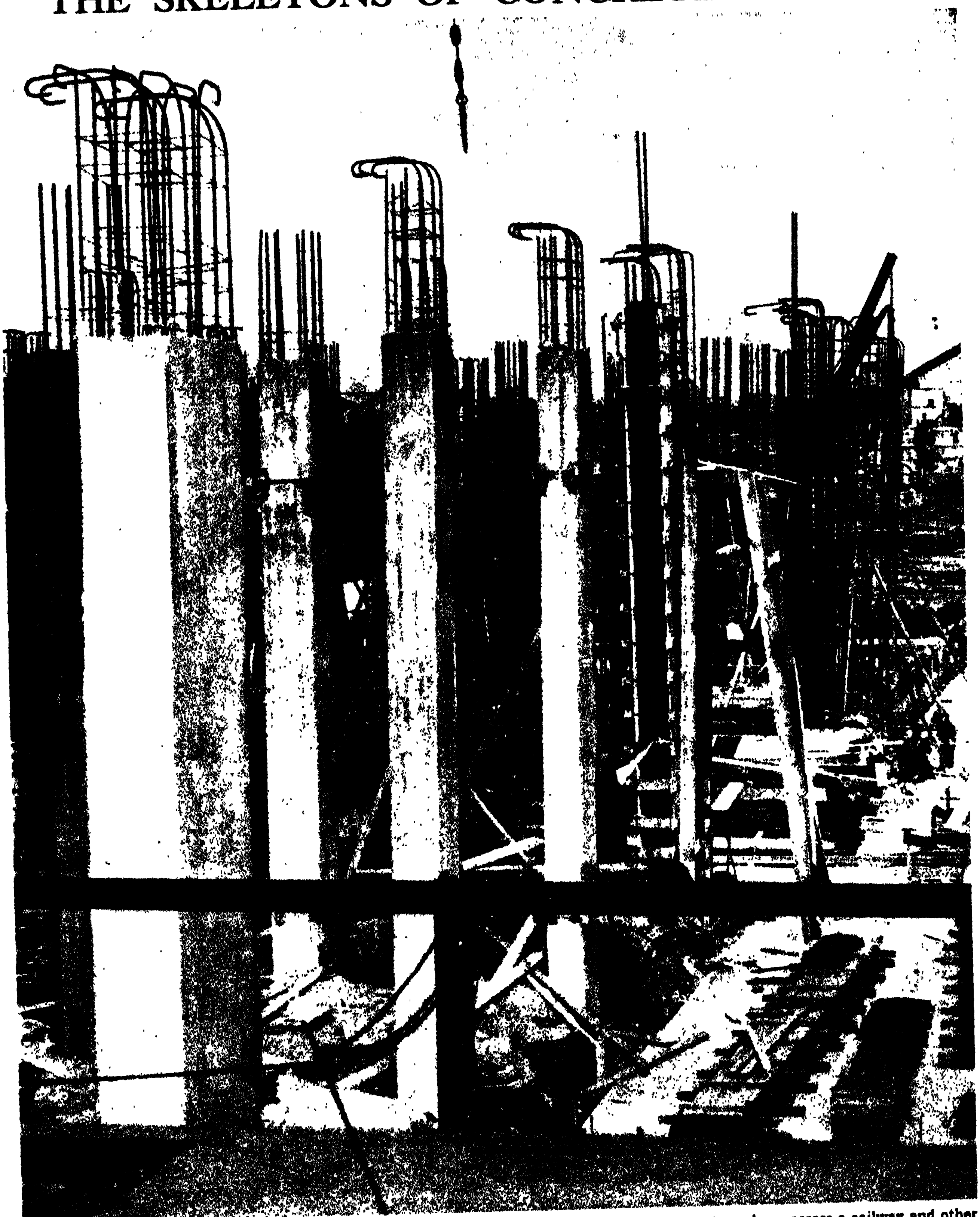


In this picture we see the explanation of why we are able to hear the whisper on the other side of the gallery. The whisper sets up waves in the air and these strike the wall of the Whispering Gallery and are then reflected at the same angle at which they strike the wall. This throws the waves against the wall once more, and again they are reflected, and so they pass rapidly right round the gallery



That the true explanation of the whisper being heard clearly on the other side of the gallery is the repeated reflection of the sound waves can be proved by a simple experiment. If a screen be placed close against the wall as shown in this picture, then the waves are intercepted and the person on the other side of the gallery with his ear against the wall hears nothing of the whisper that has been spoken

THE SKELETONS OF CONCRETE PILLARS



This photograph was taken during the building of the reinforced concrete pillars that carry a great roadway across a railway and other thoroughfares in the dock district of East London. The method of making great pillars or piles in this way is to build first of all a skeleton of steel rods laced together. Then round this a wooden framework is arranged, which serves as a mould for the liquid concrete that is poured in. The concrete flows all round the steel rods and when it is set it consists of a solid block of concrete firmly held together by the lacework of rods inside. It is stronger than a stone pillar of equal size. After the concrete is set the wooden framework is taken away and is used for making another pillar. The concrete is poured into the wooden frames in stages

THE WONDERS OF REINFORCED CONCRETE

Reinforced concrete has been called liquid stone and is now used for all types of buildings, bridges, dams, roads, and even ships. It can be formed into any shape and when it has set is as hard as granite. Because it can be mixed and used by unskilled labour, concrete is a cheaper building material than stone, which has to be cut and dressed by skilled masons. Here we read about concrete's many uses.

ONE of the greatest inventions in connection with building was that of reinforced concrete. Concrete is a mixture of broken stone, gravel or similar material, held together by cement, and enough cement must be used to fill in all the spaces between the stones. Of course the proportions of stone and sand have to be adapted to the character of the work for which the concrete is to be used.

Concrete has long been used for the making of pavements, roadways and the floors of yards, but it was when the principle of reinforcing it with a skeleton of iron or steel was devised that concrete became available for use as a building material.

Every large modern city and town has buildings of reinforced concrete, and very fine some of them look. Not only their walls, but their floors and pillars and other parts are fire-proof, and even if shaken by an earthquake they hold together with amazing tenacity. It has been found that concrete is better able to withstand earthquake shocks than is any other building material.

A French Idea

It is believed that ferro-concrete was invented by a French gardener named Joseph Monier somewhere about the year 1868. At any rate, he seems to have made water basins of concrete, strengthening them with a network of iron rods round which the concrete was moulded.

Whether it be in the construction of pillars, walls, floors, partitions, arches, domes, water tanks, dams, roofs or roadways, the idea of combining an iron or steel skeleton with a concrete body is that the concrete shall stand the compressive or squeezing strains and the steel or iron the tensile or stretching strains.

The enormous advantage of concrete used in conjunction with iron or steel is that it forms a perfect protection from rust. The metal thus does not deteriorate in strength or value. At the same time it is of supreme value as a fire-resisting substance. Steel alone not properly protected is dangerous in case of fire, for it is an excellent conductor of heat, and when the building is once alight the steel attains a high temperature and the heat is conducted to all parts quickly. The metal also becomes softened by the heat.

Concrete, on the other hand, is a very bad conductor of heat, and so when the steel building or the girder framework is enclosed in concrete the heat is unable to get at the steel. Indeed, in very high temperatures the outside of the concrete becomes changed by the heat, but in the process becomes a still worse conductor, and so the interior steel or ironwork is better protected.

The reinforcing of the concrete varies according to the ideas of different constructors, and the purpose for which the concrete is to be used. Some of the methods of reinforcing are shown in the pictures on this and the previous page.

Concrete Ships

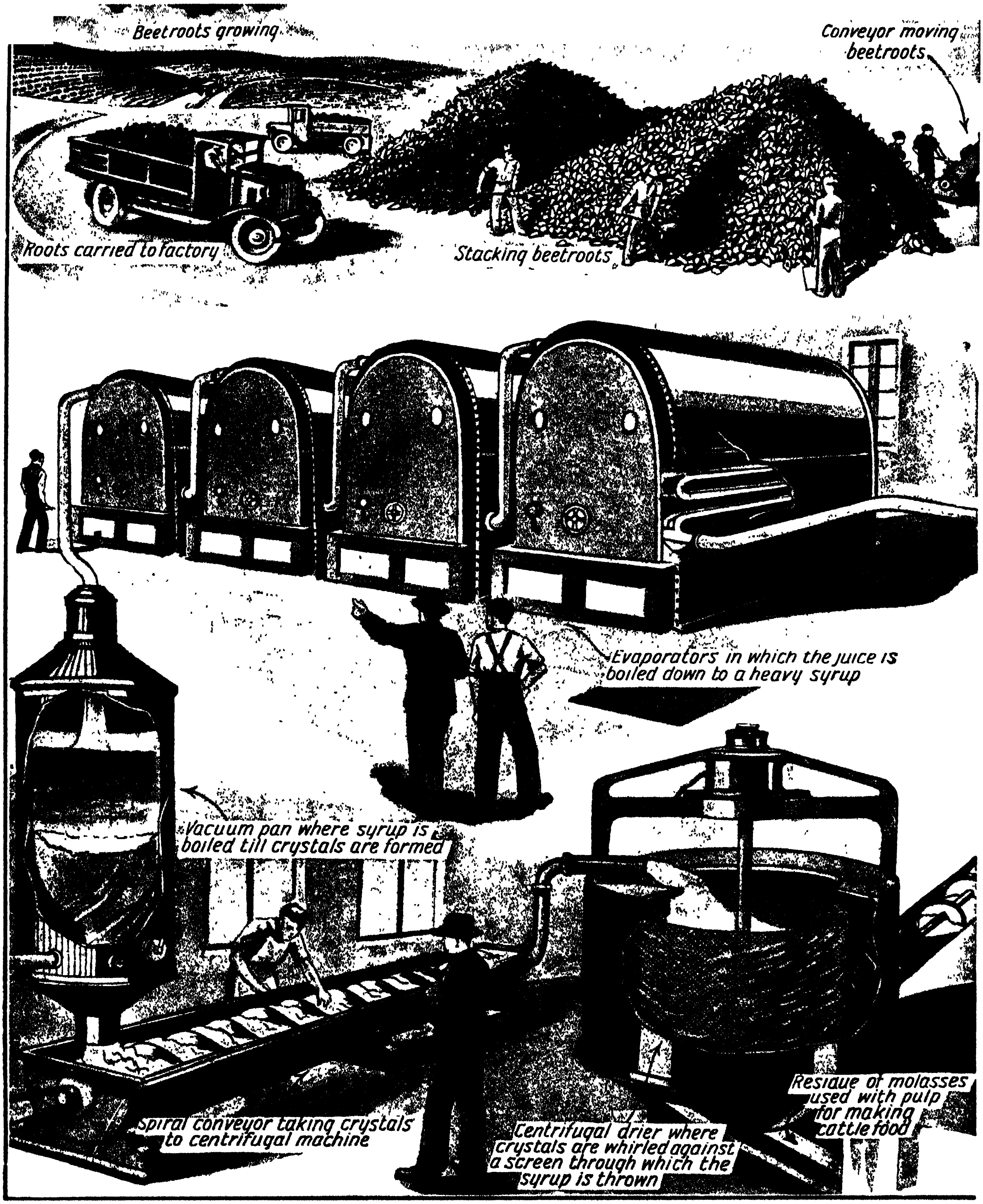
A reinforced concrete building can be erected in much less time than a building of brick or stone.

In making concrete roads a network of thick wire is laid and the concrete poured over it. This forms the best foundation for heavy traffic.

Even ships and barges have been built of reinforced concrete, the advantage of this method, as in the case of buildings, being that construction can be carried out quickly.

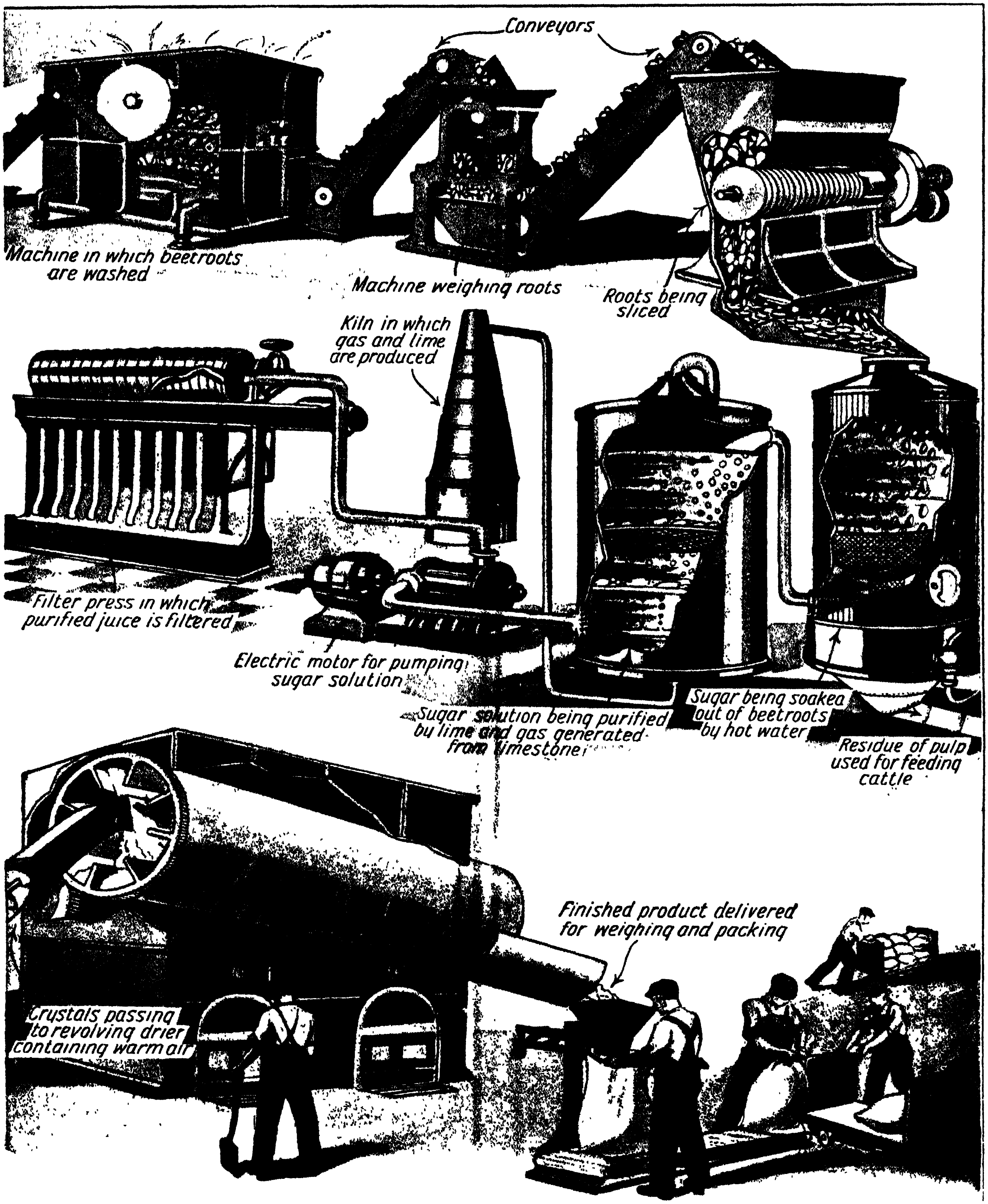
How concrete is reinforced or strengthened by means of a skeleton of iron or steel The pictures on right and left show the method of forming the reinforcement for concrete pillars, the upper picture shows a roadway being reinforced and the lower picture an arch. In all cases the concrete work has an inner skeleton of steel rods or wires to bind it and hold it together. The concrete protects the steel from rusting

HOW SUGAR IS EXTRACTED FROM THE



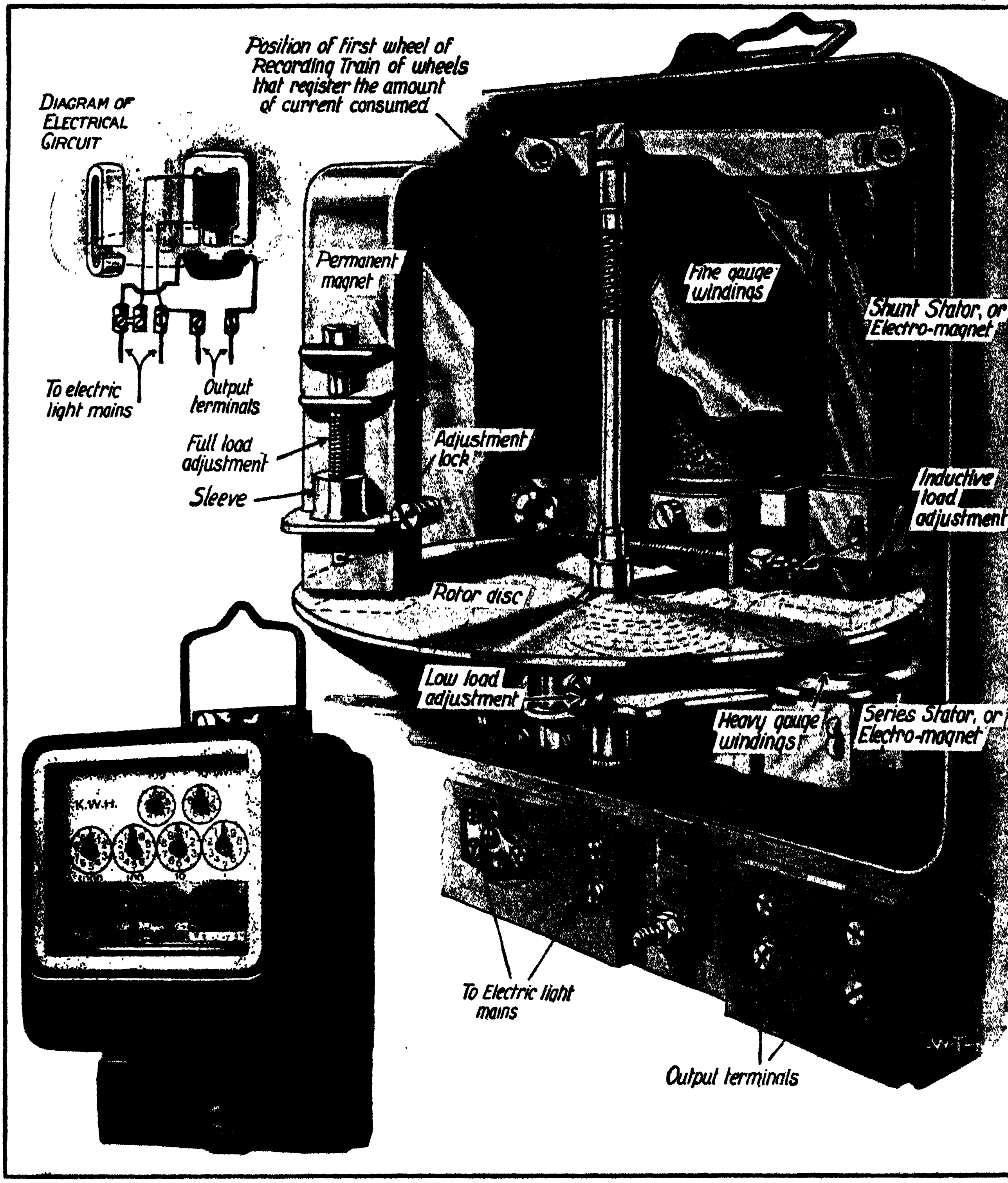
It was only at the beginning of the 19th century, under the encouragement of Napoleon Bonaparte, that sugar began to be extracted on a large scale from the beetroot. The manufacture spread till, in the early part of the present century, more sugar came from beet than from cane. Cane has now overtaken beet again, but still about nine million tons of beet sugar are produced every year, and here we see the whole process of extracting the sugar from the root and refining it for use. The beetroots are dug up and taken to the factories, where they are stacked and then passed through a machine which washes them clean. They next go through a weighing machine to an apparatus that slices them, and then they pass into a diffusion tank where in hot water the sugar is soaked out of them. The pulp residue is saved and used as cattle food, while the syrup goes to an apparatus where it is purified by lime and gas

BEETROOT AND MADE READY FOR USE



produced from limestone. It is next pumped into a filter press, where it is filtered, and then it passes to evaporators where the juice is boiled down to a thick syrup. From these it goes into a vacuum pan where it is boiled till it becomes full of sugar crystals. These while still wet are carried by a spiral conveyor to a centrifugal drier, where they are whirled round at a terrific rate, the syrup being hurled by centrifugal force through a screen. The residue of molasses is drawn off from the drier and mixed with the pulp to make cattle food. The crystals pass on to a revolving drier containing warm air and the finished product that comes out is weighed and packed for sale. No fewer than 27 countries now produce beet sugar. The beetroot is a valuable crop because there is no waste, the by-products consisting of the green tops, pulp, and molasses forming food for cattle and producing meat, milk and butter

HOW THE ELECTRIC METER IN YOUR HOME WORKS



This picture shows the inside of the electric meter which records the alternating current used in a house. It is a Ferranti meter, one of the most efficient types in the world. Electrical energy is measured in watts, a quantity proportional to the product of the current flowing and the electro-motive force which causes the current to flow in the circuit. Here is the principle on which the meter works. In the upper part is a shunt stator, which means a magnet with a coil round it joining two points of a circuit over which the electro-motive force acts. This has a coil of many turns of fine wire, connected direct or "in shunt" across the mains. In the lower part of the meter there is another electro-magnet known as a series stator, which means a magnet with two coils consisting of a few turns of heavy wire, through which the current for use in the house passes. Between these two magnets is a rotor disc, or rotating plate, on the spindle of which is a worm or screw thread which drives a train of wheels. These make the record on the dial. The combined magnetic effects of the "shunt" or electromotive coil and the "series" or current coils exert a driving force on the rotor disc making it rotate. To keep it revolving at a constant speed the disc is also acted upon by a permanent magnet, which causes currents to be generated in the disc itself. These currents act in an opposite direction to the driving force, thus setting up a braking effect. The retarding force is proportional to the speed of the disc, and the driving force to the watts passing through the meter. The two forces are equal when the speed is constant so that, omitting friction, the disc's speed is proportional to the watts passing through the meter. The disc's spindle through the geared wheels moves the pointers on the dials, and records the number of kilowatts of electrical energy passing through the circuit

HOW THE SUNSHINE RECORDS ARE MADE

Meteorology is more and more becoming an important science, and all sorts of records are kept regularly at the weather bureaus, such as rainfall, wind velocity, sunshine, cloudiness, and so on. On this page we learn how the sunshine records are made by means of instruments which record automatically the exact number of hours during which the sun has been shining on any particular day

We see in the newspapers daily records of the amount of sunshine at various seaside and other resorts. How is the record of sunshine made? It is not done by having somebody on the watch in every town making a note of the minutes and hours during which the Sun shines or goes behind a cloud. The record is made automatically by an instrument known as a sunshine recorder.

There are various types of recorders, and the most familiar used in Great Britain is known as the burnt paper recorder. A sphere of glass focuses the rays of the Sun upon a strip of paper which is arranged in a curved framework at the back. The instrument is placed at an angle facing south, and is so arranged that any sunshine that may occur between sunrise and sunset will be recorded.

Whenever the Sun is shining the glass bulb focuses the rays upon the paper which becomes charred, but if the Sun goes behind a cloud then the charring ceases till the Sun appears again. In this way the sunshine is recorded as a charred track upon the paper, and a fresh strip of paper is placed in position in the instrument every day.

Another form of instrument is known as the photographic sunshine recorder. It consists of a cylindrical box with a small opening, but otherwise light-tight. Inside the box a piece of sensitised photographic paper is placed in position. When the Sun is shining, its rays pass through the opening in the box and shine upon the paper, which becomes dark. If the sunshine is interrupted for any period, long or short, the dark track on the sensitised paper ceases. In this way a complete record is made for the day.

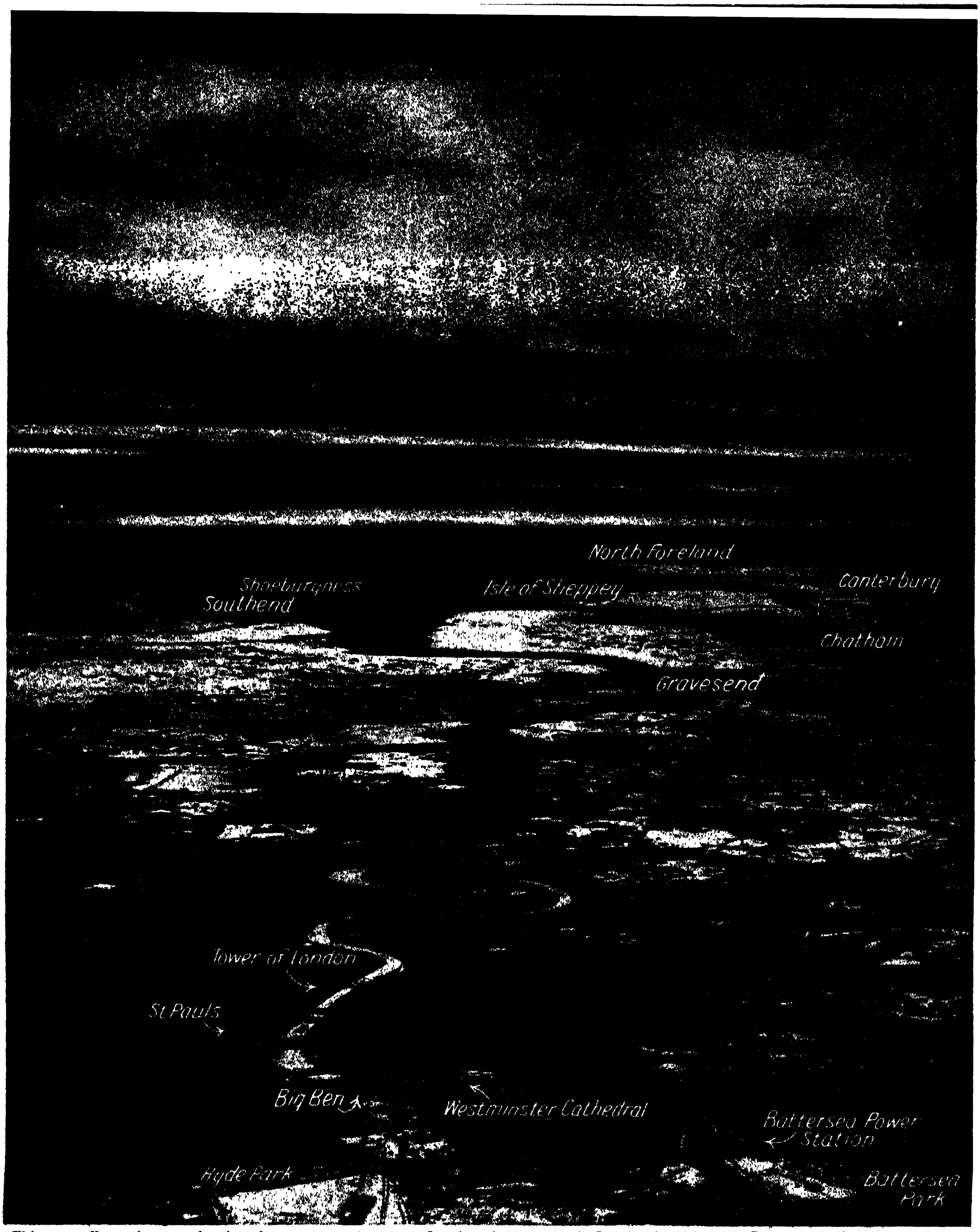
Still another form is known as the electrical contact recorder. In this a black bulb thermometer is enclosed in a glass chamber from which the air has been extracted. Two wires are carried into the stem of the thermometer.

When the Sun shines the black bulb quickly absorbs the heat, the mercury rises in the tube, and the two wires are connected, completing an electrical circuit. The recorder is placed on the roof and the wires are carried into an office below, where they operate a pen which makes a graph on the paper of a revolving drum. If the Sun ceases to shine the mercury drops, contact is broken, and the line becomes straight.

This electrical form of sunshine recorder is the type of instrument that is used at its various stations by the United States Weather Bureau, which finds it very accurate and efficient.

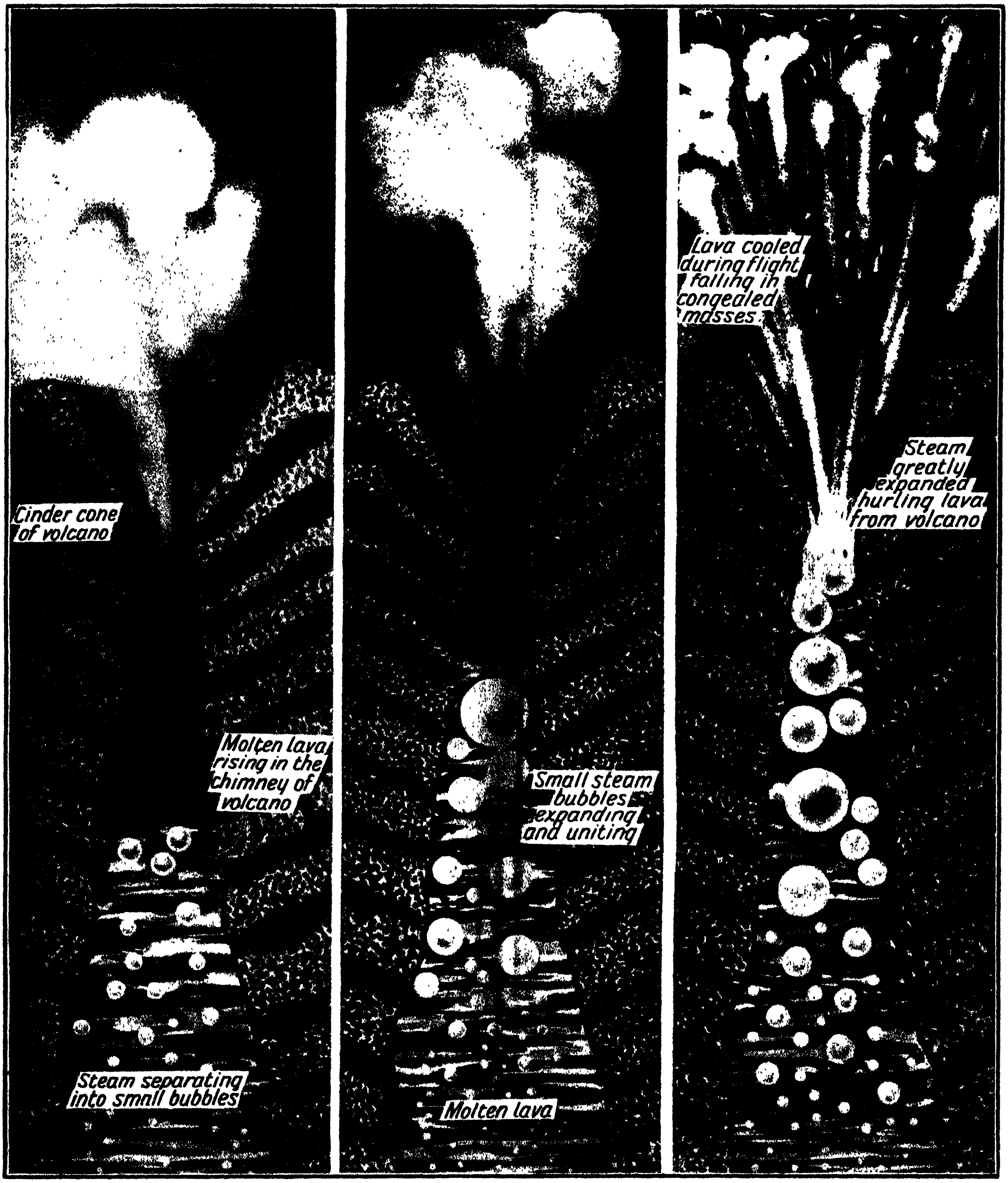
Placing the strip of paper in position on a burnt paper sunshine recorder. The exact amount of sunshine that occurs each day from sunrise to sunset is recorded by means of a continuous or broken line of charring on the paper

LOOKING AT THE NORTH SEA FROM LONDON



This marvellous photograph taken from an aeroplane over London shows not only London itself but the Thames winding away through the country and emptying itself into the North Sea beyond the Nore. We see on one side the Isle of Sheppey and the Kent coast passing away to Thanet, and on the opposite side of the estuary of the Thames the coast of Essex with Canvey Island, Southend, Shoeburyness and Foulness Island. The photograph was taken with a plate sensitive to infra-red rays which penetrate mist and fog. Various places visible have been marked, and the bridges over the Thames in London can be recognised. Notice how the land not built on, including the parks, stands out white. On page 358 there is an even more remarkable photograph taken from a rocket at a height of 100 miles and showing the curvature of the earth over a distance of 900 miles.

WHY THE VOLCANO THROWS OUT MOLTEN LAVA



These pictures explain why it is that a volcano hurls out molten lava from its crater. The popular idea that a volcano is a burning mountain is quite wrong. What in the daytime appears to be smoke hovering over the crater is really a steam cloud mixed with very fine dust, and what appears to be fire at night is the reflection on the cloud of the molten lava deep down in the crater. From some volcanoes like those of Hawaii the lava overflows and pours down the side of the crater in a steady stream, but in others like Stromboli in the Mediterranean it is ejected from time to time by a series of violent explosions. The crater shown here in section is supposed to be that of Stromboli. Currents of hotter lava rise in the chimney from below, and the steam contained in it being relieved of pressure begins to separate into bubbles, as shown in the first picture, and these expand as they rise. Then they flow together, as shown in the second picture, and as they get near the top their speed is increased, and their expansive energy causes them to explode and hurl the lava high into the air, as shown in the right-hand picture. The lava cools during its flight, congeals into rocky masses and ash, and falls on the cone, which is thereby increased in diameter and height. It is the expanding steam which hurls the lava out

WHY WE HAVE TO PLOUGH THE LAND

The soil is the layer of mould which lies at the surface of our Earth's crust, and it is really the most important part of the Earth, for men, beasts, birds, insects and plants are alike dependent for their very life on what the soil produces.

The soil rests upon the harder part of the Earth's crust, which is known as the sub-soil, and if, in some great cataclysm, the whole of the soil of the Earth should be washed away we should most of us, if not all of us, perish of hunger. In some countries men have cut down forests, with the result that when the rains came they have washed the soil down the sloping hills till these became bare and hard, and nothing would grow.

The Beginning

Men of science believe that in far distant days the surface of the Earth was hard rock, but wind, and weather, and sun, and rain broke up the surface of this hard rock into powder, and thus formed a soil on which lowly plants could grow. Then the roots of these plants and various substances that resulted when they decayed broke up the rock still more and gradually a soil was formed on which more important plants could take root and from which they could draw nourishment.

If the soil is left to itself the crops of useful plants are poor. Man finds it necessary to till the soil, that is to prepare it by ploughing and in other ways, so that is shall bring forth more and more food for the use of himself and his cattle. In the old days the soil was not tilled very well, with the result that the crops were poor and the mass of people rarely knew what it was to have enough to eat. This was the case in England and the bleaker lands, at any rate. The more carefully the soil is prepared the more will it produce for the use of man and beast.

If the soil is left to itself it becomes hard and the roots of plants find it difficult to make their way in the earth as they seek moisture and nourishment. That is why the land has to be ploughed at regular intervals so as to break up the ground and allow the air and rain to get in and supply fresh nourishment. It is of great importance that the soil should be gradually deepened, so that the roots of plants may find it easier to travel in search of moisture and food.

This gradual deepening of the soil is done by ploughing.

Ploughing the soil so that the sunshine and air and rain can reach down into the earth and the ground may be broken up for the roots of plants to make their way about in it

The plough cuts a furrow and turns over the soil, so that the air can get to it. Then the harrow breaks up the clods into smaller pieces and the roller crushes them still smaller. In this way the air is able to circulate freely, doing its good work in the earth.

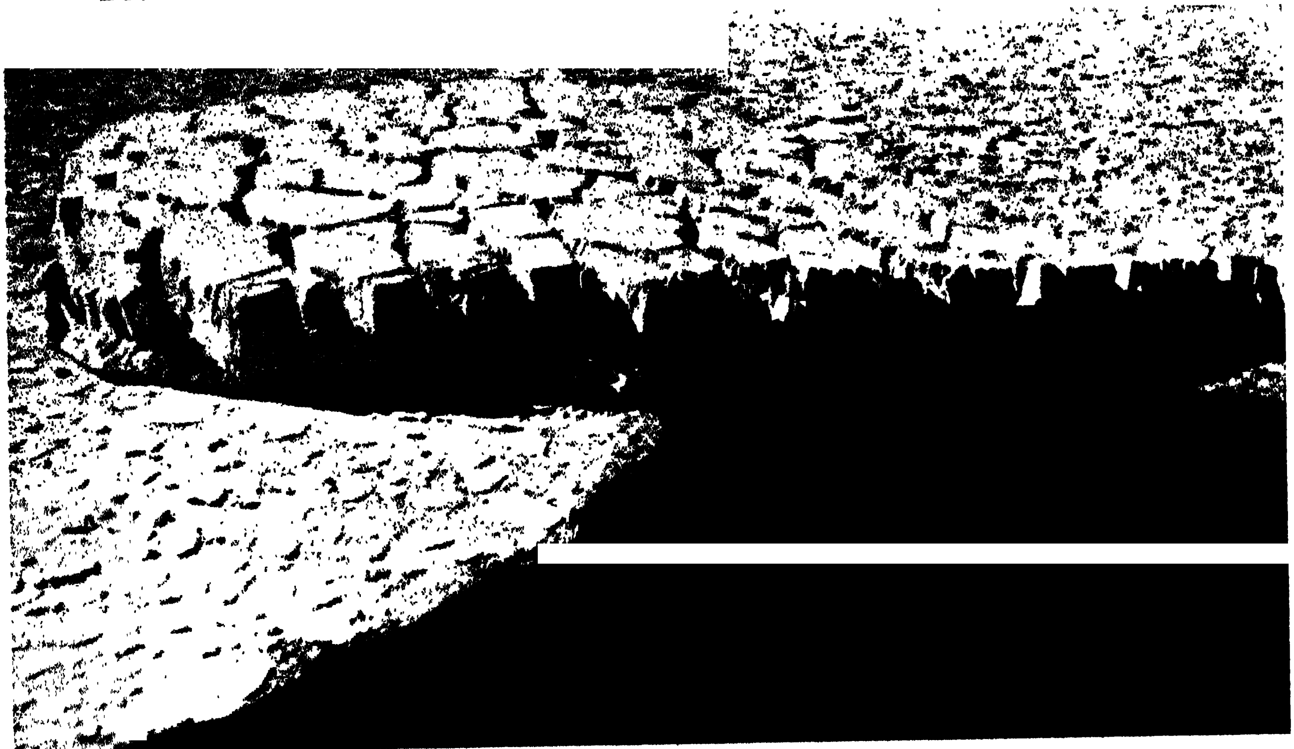
If air is necessary to a fertile soil, so also is water The soil must be able to hold enough moisture to carry the plant through hot, dry spells of weather, for the plant gets all its water through its roots, which are embedded in the soil. These spread about in all directions, and go deep down in search of water, and the more we help them in their search by preparing the soil the more they will help us by producing strong, healthy plants above ground. They obtain their food for the building of new tissue from the soil. There is a constant stream of water travelling through the plant, going up through the roots of the stem and passing out into the atmosphere through pores in the leaves.

A Safeguard

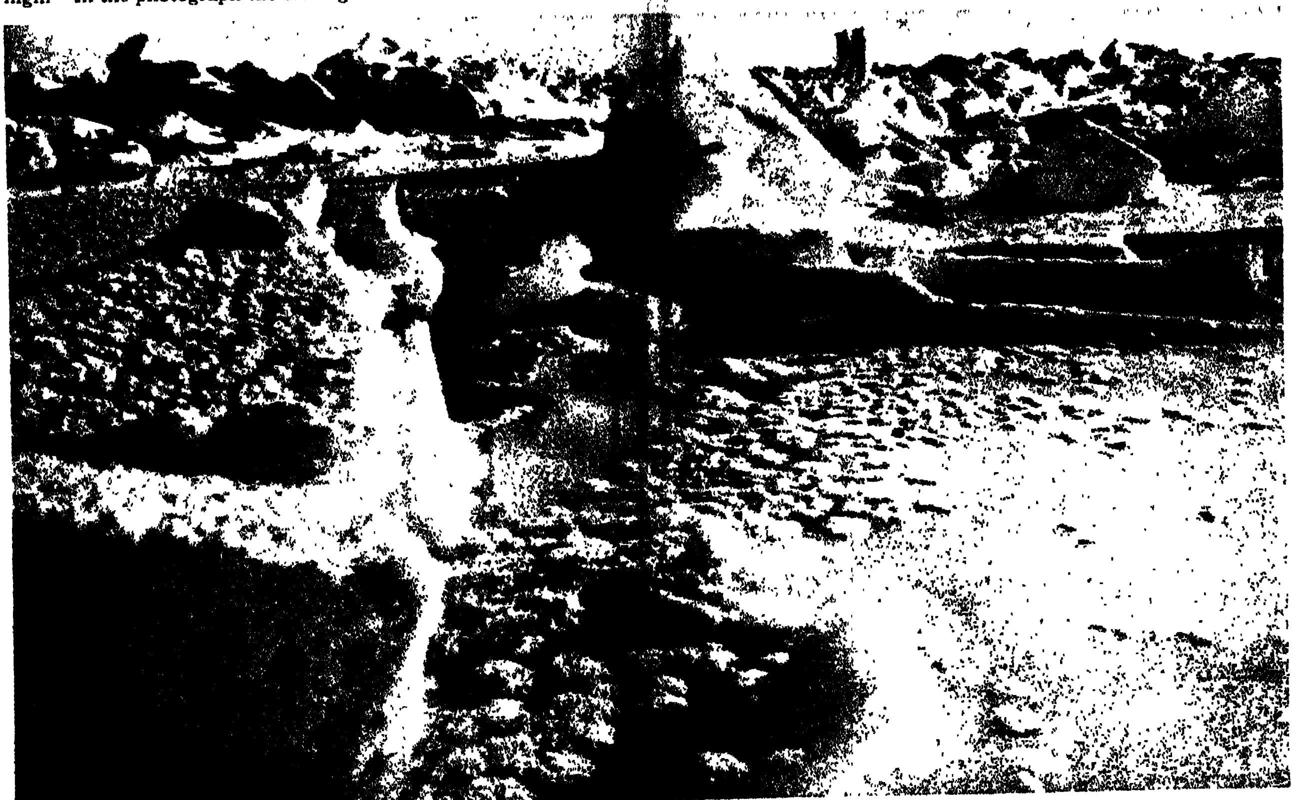
We know how in hot, dry summers, when there is not much rain and the soil is very dry, the leaves shrivel up. This is a provision of nature which enables the plant to retain any moisture it may have, instead of letting it pass off freely as in normal times into the air. The farmer keeps his soil in a suitable condition for holding a supply of water for use in dry and hot weather, by deep ploughing and good tilling.

Of course, the earthworms, as we read in another part of this book, do a great deal of work in preparing the soil, and make it suitable as a place in which the plants can grow, and from which they can draw nourishment. Charles Darwin made a life study of the earthworm.

THE SPARKLING SCENERY OF THE ANTARCTIC

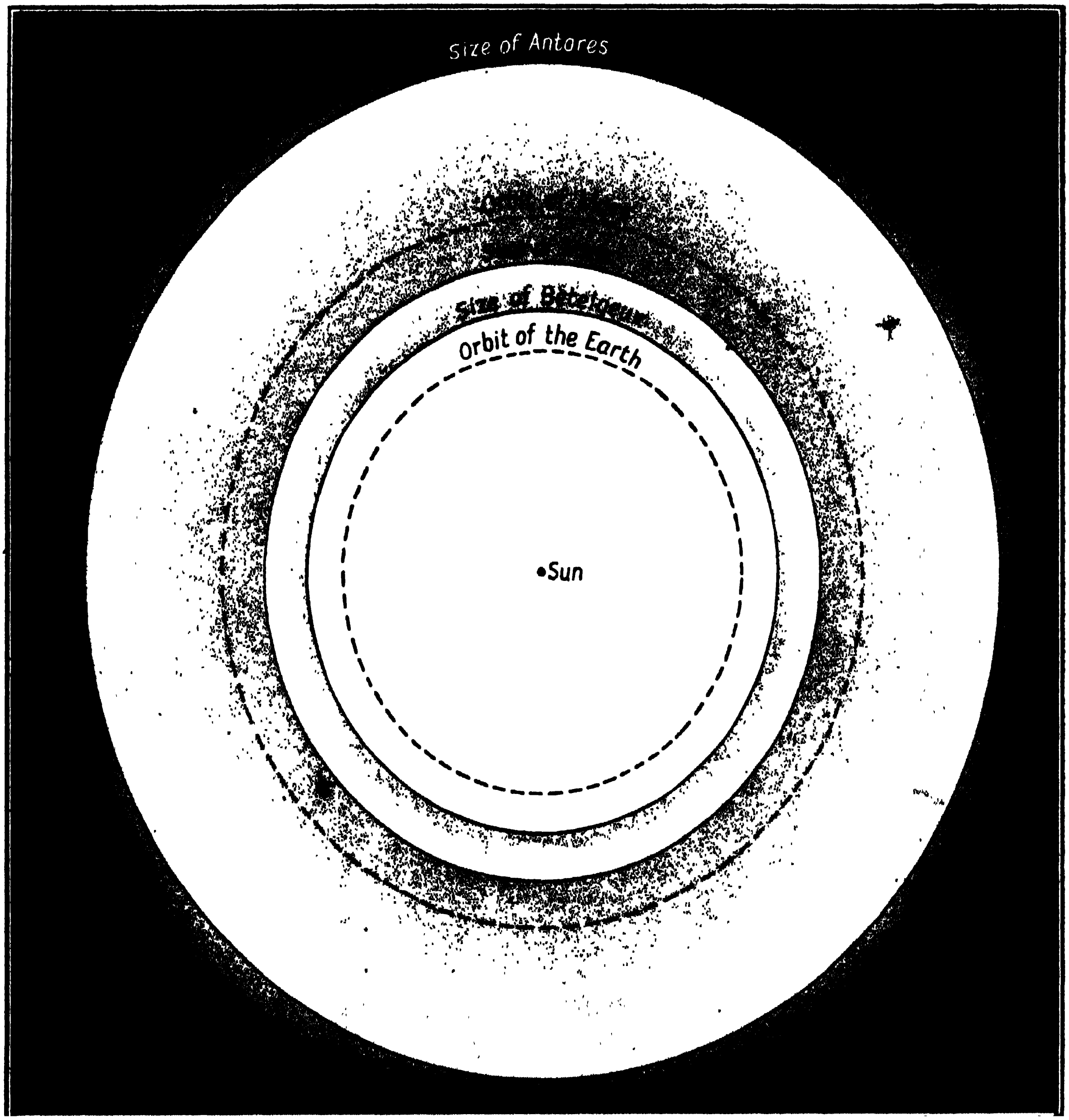


Some wonderful ice effects are to be seen in the Antarctic seas, and the photographs on this page, taken during Sir Douglas Mawson's expedition in the *Discovery*, are typical of that bleak and lonely part of the world. In this picture we see a vast iceberg which must have weighed millions of tons. Its enormous size may be gathered from the fact that the face standing out of the water is 200 feet high. In the photograph the iceberg looks like a small slab of ice standing a foot out of a puddle. It is difficult to visualise it as so vast

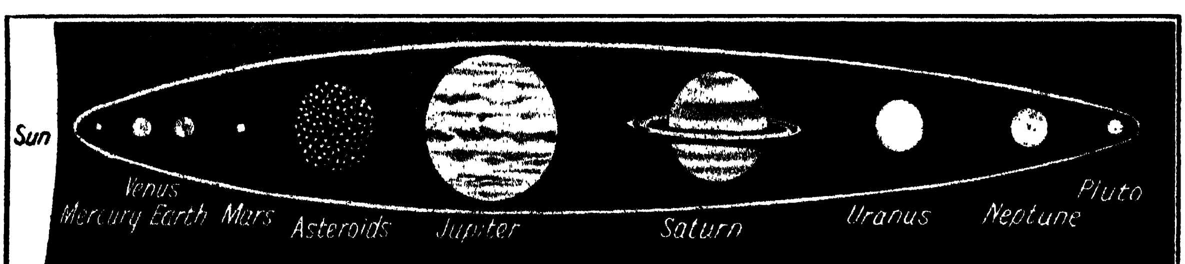


Here is another view of Antarctic scenery taken during the same expedition. The photograph shows what looks like a fairy garden of crystal blossoms. The floating fragments are parts of the shattered ice-floe and the ice-crystals take on fantastic forms like rosettes. Old travellers like Captain Cook must have observed such scenery, but by means of photography, perfected as it is to-day, anyone who has never been out of England can see what the distant South is like just as the explorers do in its loveliness and grandeur

THE ENORMOUS SIZE OF SOME STARS



By means of a wonderful instrument known as the interferometer, which is described on page 788, some of the distant stars have been measured, and truly astonishing are the results, as we can see in this picture-diagram showing some of the stars with the Sun and the orbits of the Earth and Mars drawn to the same scale. It will be seen that some of the stars measured are much bigger in diameter than the Earth's orbit, while one of them is not only bigger than the orbit of Mars, but more than twice as great in diameter as the Earth's orbit. Antares, the chief star in the constellation of the Scorpion is the biggest star that has been measured so far. Stars vary much in size but not in mass, and consequently their densities must be very different. The densities of the stars vary from several times that of iron to one-millionth that of water. It is difficult for us to imagine matter so enormously drawn out



If the planets are arranged in their right order there is a remarkable sequence of size. They fit into a figure shaped like a cigar, and the suggestion of scientists is that some star passing our Sun in the past drew out some of its substance, which cooled into the planets

FINDING THE DISTANCES OF THE STARS

We may wonder how the distances of such far-away objects as the stars can be measured by men on the Earth Yet this marvel has been performed, and here we read about the method that is used. It is known as parallax, a name from a Greek word meaning to " vary " or " wander." Parallax is really a method of measuring how far away a distant object is by noticing its variation in position when viewed from different angles

THE nearest star so far as we know is 25 million million miles away, and its light takes four and one-third years to reach our Earth. How is it that men of science have been able to measure the distance of this and other stars ?

Well, in the case of the nearest stars the measurement is done in exactly the same way as a Boy Scout measures the distance of a church or tree which is on the other side of a wide river.

The Boy Scout draws a base line on his own side of the river, and measures it, and then from the ends observes the church tower or tree and notes the angle which it makes with his base line. Thus there is a triangle of which he knows the length of the base and the size of the angles at the base. With this information and some slight knowledge of trigonometry he can work out the distance of the church or tree.

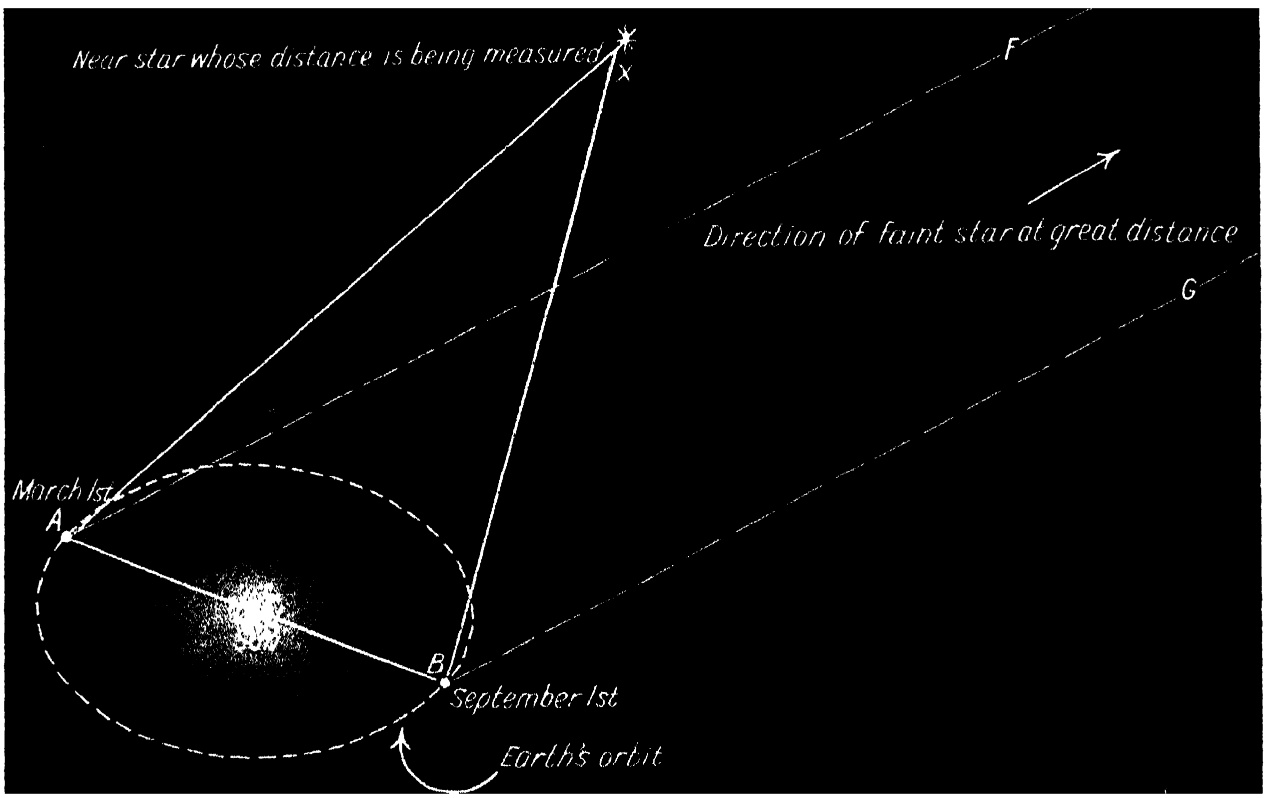
Even the nearest of all the stars, which is known as Proxima Centauri, is so far away that no line which we could take on the Earth itself would be long enough to form the base of a triangle whose apex was the star. How is it possible then to get a base line long enough to form a triangle ?

This is obtained in a very ingenious way. Our Earth travels round the Sun in an orbit, and the diameter of this orbit is 186 million miles. So what men of science do is to observe the star whose distance away they wish to measure first from one side of the orbit, say on March 1st, and then from the other side of the orbit, say on September 1st. They look at this star and then at another more faint and distant star that appears to one side. Lines from the two stars to the point of observation on the Earth form a certain angle.

Now when the Earth reaches the other side of this orbit the scientists observe the star whose distance away they wish to measure, and the faint and distant star, and find that though the faint star owing to its vast distance does not appear to have changed its position at all, the other star has changed slightly. The width of the Earth's orbit has been sufficient to make a slight difference in one case, but not in the other.

Knowing the length of the base line and working out the angles very accurately by means of delicate instruments the distance of the nearer star can be calculated.

The distances of the farther stars can be worked out by means of the spectroscope, that wonderful instrument about which we read on pages 451 and 843, and how this is done is explained in another part of this book.



This diagram shows the method of measuring the distance of a star by what is known as parallax. X represents the position of the star whose distance is to be measured. A faint and very distant star lies somewhere in Space on the line AF, and the lines from the two stars make an angle XAF. Six months later, when the Earth is on the other side of its orbit, 186 million miles away, the same two stars are observed. The faint star is so distant that there is no change whatever in its position, but the position of the nearer star has changed a little. The lines from the two stars now make the angle XBG. The difference between the angles XAF and XBG is equal to the angle AXB. Astronomers, knowing this angle and the size of the base line which is the diameter of the Earth's orbit, are able by trigonometry to work out the distance of the nearer star. This picture has been adapted from a diagram by Mr. W. M. Smart

WHY THE EVENING SHADOWS LENGTHEN

As we know, the shadows cast by various objects such as trees and houses and telegraph posts and ourselves are long in the morning, but get shorter and shorter as noon approaches and then lengthen once more as evening draws on. A small child will cast a shadow in the evening that is much longer than the height of any man, while a man's shadow becomes as long as a tree.

The reason for this lengthening of the shadow is explained in the picture-diagrams on this page. When the Sun is high in the heavens it shines down much more directly than when it is low on the horizon in the morning or evening. Consequently the rays of light from the Sun strike the ground at a much less acute angle than they do when the Sun is near the horizon.

The effect of this is that the rays are intercepted much nearer the point where they would strike the ground. At evening when the Sun is low the rays, coming more slantingly, reach the ground at a greater distance from any object over which they pass. As a result the shadow of a child's head intercepting the rays is thrown far away on the ground, and other parts of the shadow are similarly extended.

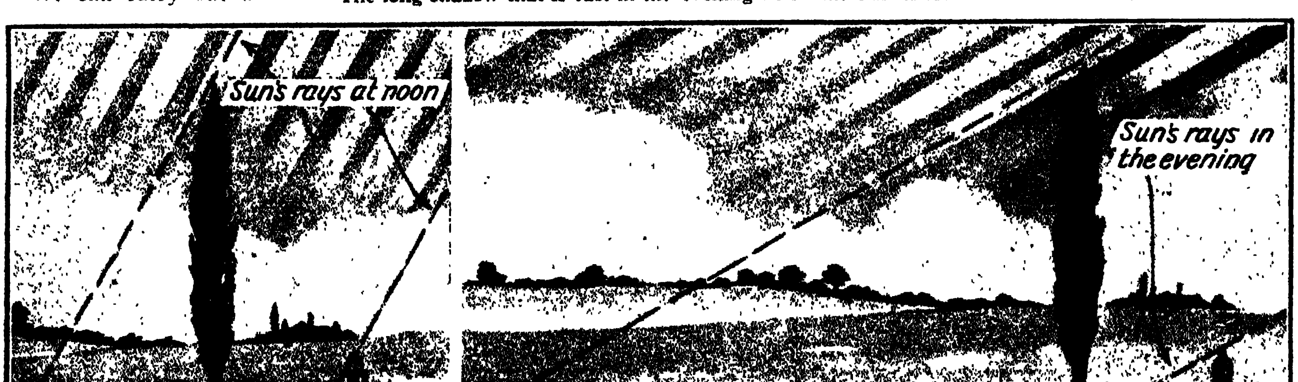
We can carry out a series of simple experiments in a darkened room to illustrate this, using a small flash lamp to represent the Sun. Any small objects can be used for casting the shadows and if we use tin soldiers or other models of human beings the experiment is the more interesting.

We arrange our objects on the table and then, having put the room in darkness, we turn on our flash lamp. First of all we hold it over the objects, shining it down upon them from above, and we find that the shadows have practically no length at all, as is the case in the Tropics at noon when the Sun is right overhead.

Next we move the light a little lower down, and the shadows are then cast along the table in the direction away from the light. Gradually we lower the lamp still farther, and as we do so the shadows lengthen just as they do on the Earth when the Sun sinks to the horizon. When we hold the lamp just above the table's edge the shadows of the little tin soldiers will be longer than the table itself.

It was by the lengthening of the shadow that men in early days marked the passing of time. In the Bible we read how "A servant earnestly desireth the shadow," meaning the lengthening which marks the end of work.

The long shadow that is cast in the evening when the Sun is low



These diagrams explain why the shadows are longer in the morning and evening than in the middle of the day. When the Sun is low on the horizon its rays strike more slantingly than when it is high up at noon and consequently the shadow is thrown farther

THE FAMOUS BOSTON TEA PARTY

Most people have heard of the Boston Tea Party, but how many people know what it really was, why it occurred, and how it led to the breaking away of England's American Colonies and the birth of a new nation under the name of the United States? This "tea party" marks an important turning point in the world's history, and the story of it is told in these pages

A SHORT time before he fell at Quebec the Marquis of Montcalm, the French commander, declared that if the English conquered Canada the American colonies to the south would break away from the Mother Country. It was a true prophecy, and within fifteen years of the taking of Quebec the American Colonists had begun their fight for independence.

So long as the French were in Canada the Colonists were only too glad to have the help of the English army and navy to protect them. But once the French menace was removed and the thirteen Colonies no longer stood in need of English protection, they began to find the control exercised over them by the Mother Country irksome.

When people talk about the American War of Independence as a great fight for freedom by people who were oppressed politically they are talking nonsense. The American Colonists were as free politically as the people of Canada or Australia to-day.

The Stamp Act

But there were certain restrictions on trade and commerce which were exercised by the Mother Country, and as these affected their pockets the Colonists had a great desire to be free of them.

All the foreign trade of the Colonies, for example, with Europe had to be conducted in English ships. Then in 1765 a Stamp Act was passed which declared that all legal documents in America must be written on stamped paper, which had paid a duty, and the duty went to the English Government.

In passing this Act the English Government had no idea of infringing the liberties of the Colonists. An English army had to be kept in America to protect the Colonies, and it was unfair that the whole of the cost of this should fall upon the English people. It was not unreasonable to expect the Colonists to pay something towards the cost of the English forces.

But unfortunately the Colonies all had separate governments, and there was no way of passing a law which should be binding on all except through the English Parliament. Such laws had often been passed, and the Colonists had raised no objection. But now that they no longer needed the English army the Colonists took up a high line, and declared that as they had no representation in the English Parliament that body could not tax them. They refused to use the stamped paper, and in 1766 the Stamp Act was repealed.

But Lord Rockingham, the Prime Minister, had an Act passed which declared that the British Parliament really had the right to make laws for the Colonies. It was a silly thing to do, for in the strained relations it would have been better to let sleeping dogs lie.

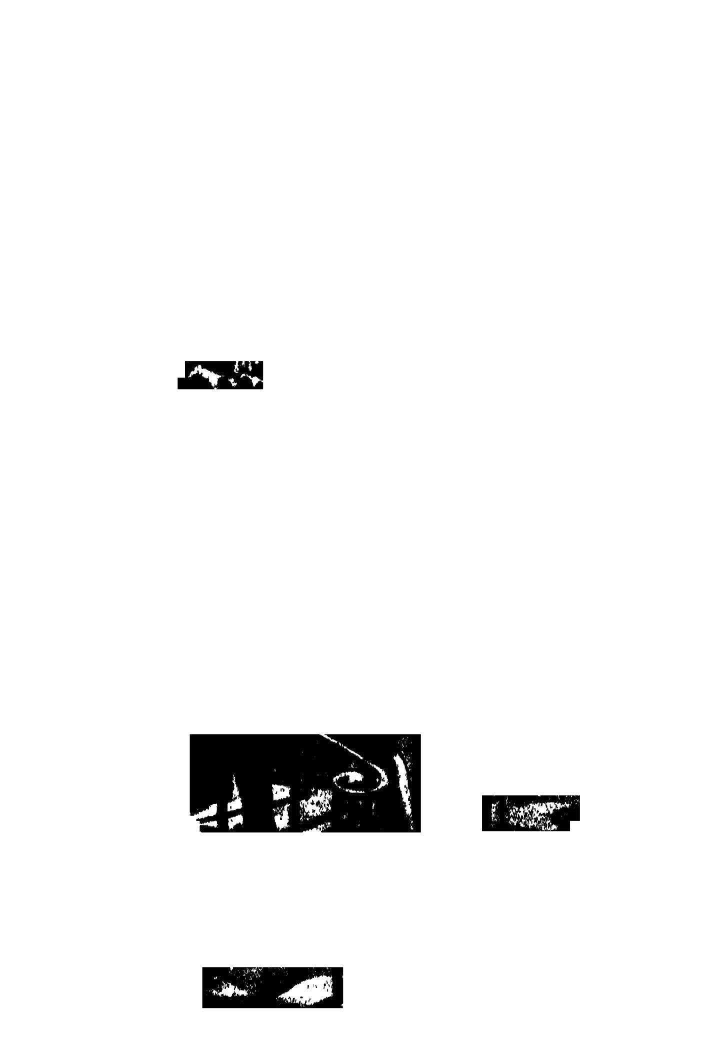
Soon afterwards fresh duties were imposed on glass, paper, colours and tea imported into America, and at once there was a loud outcry. The Americans declared that the taxes should not be paid, and in 1770 there were riots in Boston. British soldiers fired upon the mob and killed several of the rioters. The affair was at once denounced as a "massacre," and public opinion was worked up to fever heat against the Mother Country.

A Tax on Tea

The English Government was weak, and Lord North, who was now Prime Minister, repealed all the duties except a small tax of threepence on every pound of tea entering America. He maintained this in order to insist upon the right of England to levy taxes on the Colonies.

But the Colonists objected, not to the amount of the taxes, but to the taxes themselves, and they made up their minds to resist.

And now occurred the famous Boston Tea Party, which was really the small beginning that led to the formation of the United States as an entirely independent country.



A knock was given on the door of each person commissioned to deal with the tea and a summons was left ordering the inmate to appear without fail at Liberty Tree on the following Wednesday morning

The Colonists determined that none of the taxed tea should be allowed to land. A committee was formed in Boston which began to publish extravagant statements to inflame the people. "What oppressions," they asked in a circular to the other towns of the colony, "may we not expect in another seven years if through a weak credulity, while the most arbitrary measures are still persisted in, we should be prevailed upon to submit our rights to the tender mercies of the ministry? Watchfulness, unity and harmony are necessary to the salvation of ourselves and posterity from bondage. We have an animating confidence in the Supreme Disposer of Events that He will never suffer a sensible, brave and virtuous people to be enslaved."

It all sounds very ridiculous when one remembers that there was no question of political oppression at all. Of course what annoyed the Colonists was that the English tried to restrict the growth of manufactures in the Colonies.

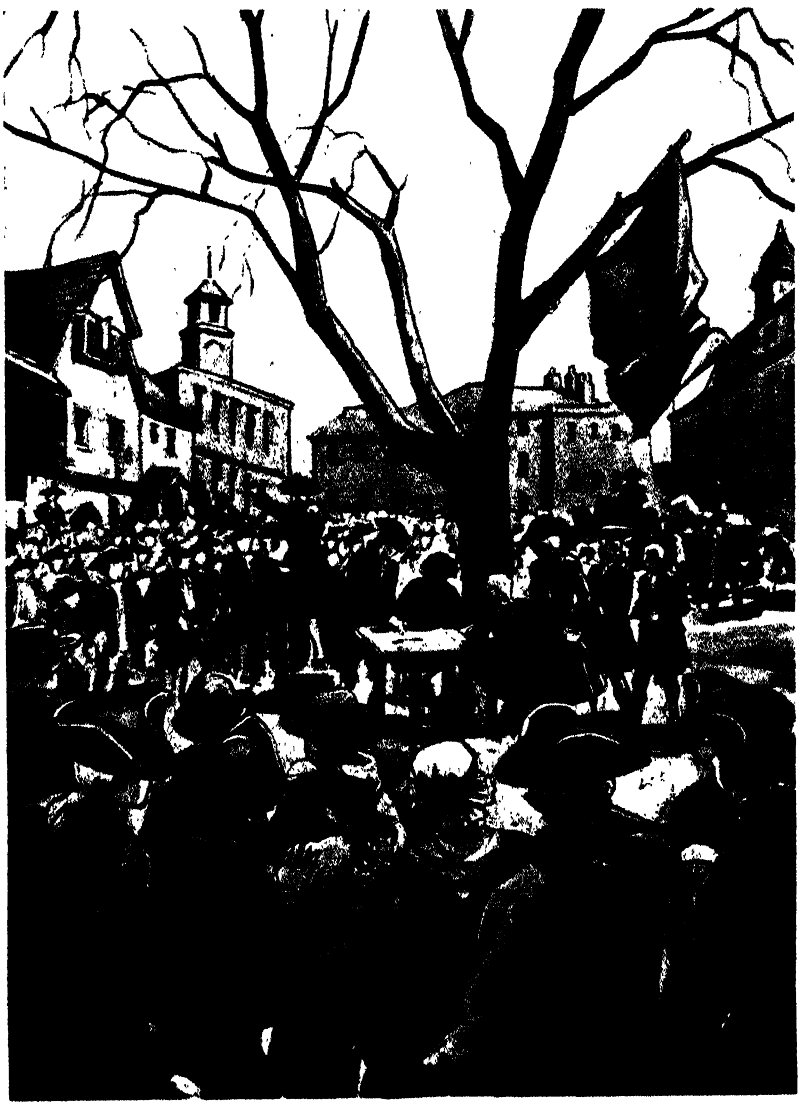
Independence

Samuel Adams, a leading politician of Massachusetts, demanded that there should be an annual congress of American states to frame a Bill of Rights, or to "form an independent state, an American Commonwealth." Union, he said, was the only hope for America. It must be explained that at this time all the thirteen Colonies were independent of one another. Each had its separate legislature and government, and in many cases they were trade rivals.

Meanwhile the East India Company was sending a consignment of tea to America. Philadelphia, then the largest town in the Colonies, began the work of preventing a landing. Its inhabitants met in the State House and passed resolutions denying the claim of the English Parliament to tax America, and it especially condemned the duty on tea.

But it was at Boston that the great issue was really to be tried. Tea ships were on the high seas and would soon arrive, and the Governor himself, under the name of his sons, was one of the consignees.

On the night of November 1st a knock was given on the door of each of the people commissioned by the East India Company to deal with the tea, and a summons was left ordering them to appear without fail at Liberty Tree on the following Wednesday at noon, there to resign their commissions. It all sounds very much like the Ku-Klux Klan of later days.



On the appointed day a large flag was hung on a pole at Liberty Tree and the town officials with 500 citizens gathered at the spot

On the appointed day a large flag was hung on a pole at Liberty Tree, and the bells in the various meeting-houses were rung. The town clerk and other officials, with 500 citizens, gathered at the spot. The people who were to receive the tea did not turn up, but held a meeting in a warehouse close by. The citizens therefore sent a deputation to interview them and extract a promise not to sell the tea but to return it to London in the ships in which it came out.

The consignees, however, refused to comply with the request, and when the meeting at Liberty Tree heard this the people shouted "Out with them, out with them!" They were, however, persuaded to refrain from any form of violence for the time being.

At a meeting a day or two later there was some talk of "taking up arms," and the suggestion was received with hand-clapping.

At the same time the people of New York had formed a Vigilance Committee, and declared that no tea should be landed there. Pilots were ordered not to bring tea ships above the Hook, and a body described as "the Mohawks" was notified to be in readiness in case of their arrival.

Fiery Words

During this time the tea ships were on their way. The leaders at Boston continued to inflame the people. A letter was sent to various towns which said "Brethren, we are reduced to this dilemma, either to sit down quiet under this and every other burden that our enemies shall see fit to lay upon us, or to rise up and resist this and every plan laid for our destruction as become wise freemen." Of course, to talk of threatened destruction was ridiculous and untrue.

Meanwhile the argument went on as to whether the tea should be landed. "Nothing will satisfy the people but re-shipping the tea to London," said the Committee. The men of Cambridge assembled on November 26th and voted unanimously "that as Boston was struggling for the liberties of their country, they could no longer stand idle spectators, but were ready on the shortest notice to join with it and other towns in any measure that might be thought proper to deliver themselves and posterity from slavery."

So the indignation was worked up by exaggerated and untrue statements of this kind. Then on Sunday the 28th the

first tea ship, the *Dartmouth*, appeared in Boston Harbour with 114 chests of the East India Company's tea on board.

Here was a dilemma, for it was the practice in New England to keep the Sabbath, as they called Sunday, very strictly. If the tea were once landed it would be impossible to send it back, but the owner of the *Dartmouth*, who was a Quaker, promised not to enter his ship till the Tuesday.

A meeting of the people was summoned for Monday morning, and it was the largest gathering ever held in Boston. The gathering of 5,000 persons resolved unanimously that "the tea should be sent back to the place from whence it came at all events, and that no duty should be paid on it."

But there were other counsels. "The only way to get rid of it," said one, "is to throw it overboard."

Negotiations went on all day, and the next morning the consignees gave their answer. "It is utterly out of our power to send back the teas, but we now declare to you our readiness to store them until we shall receive further directions from our constituents." This meant that they wanted to notify the British Government of the state of things, and the citizens became more angry than ever.

Keeping Watch

At last the Quaker owner of the *Dartmouth* and the master of the ship promised that the tea should return as it came without touching land or paying duty. Then a similar promise was exacted of the owners of all the other tea ships whose arrival was daily expected.

It was now thought that the matter would end peacefully, and every shipowner was forbidden on pain of being deemed an enemy to the country to import any tea from Great Britain till the Act taxing it should be repealed.

But the people were still suspicious, and six persons were chosen as post-riders, to give notice to the country towns of any attempt to land the tea by force. At the same time a military watch was regularly kept up by volunteers armed with muskets and bayonets, who at every half-hour in the night regularly passed the word "All is well," like sentinels in a garrison. Should there be any trouble by night the bells were to be tolled and this was to be the signal for a general rising.

The community was evidently getting near to civil war or rebellion, for it must be remembered that right through the conflict there were tens of thousands of loyalists who did not believe in opposing the English Parliament.

But a difficulty arose. The rest of the cargo had been landed, but the *Dartmouth* could not receive a clearance with the tea on board, that is, it could not receive an official certificate that its goods had been unloaded at the Custom House. Further, on the twentieth day from its arrival it would be liable to seizure if not cleared. To complicate matters still further, two more tea ships arrived and anchored by the side of the *Dartmouth*.

During the next few days meetings were held in many parts. The people became wilder than ever, and they talked of assisting Boston even at the risk of their lives.

On December 11th the owner of the *Dartmouth* was summoned before the Boston Committee to explain why he had not kept his engagement to take his vessel and the tea back to London within twenty days of its arrival. He pleaded that it was out of his power. "The ship must go," was the answer; "the people of Boston and the neighbouring towns absolutely require and expect it."

But the clearance could not be obtained, and the vessel could not put to sea without it. Indeed, the Governor gave orders to load the guns at the castle so that no vessels except coasting ships might go to sea without a permit.

Nearer and nearer came the decisive day. The people were really getting ready to fight. "We trust in God," wrote the men of Lexington, "that should the state of our affairs require it we shall be ready to sacrifice our estates and everything dear in life, yea, and life itself, in support of the common cause."

The Fatal Day

Still the controller of the Custom House refused to grant the ship a clearance till the tea had been unloaded. At last, the morning of Thursday, December 6th, 1773, began to dawn, the day which was to prove the most momentous in American annals. Meetings were held and resolutions were passed to abstain wholly from the use of tea.

In the afternoon 7,000 people gathered in a dimly lighted church and voted unanimously that the tea should not be landed.

The owner of the *Dartmouth* appeared and declared that the Governor had refused him a pass because his ship was not properly cleared. When he had finished Samuel Adams rose and said, "This meeting can do nothing more to save the country."

Then a great shout was heard

The Governor gave orders to load the guns at the castle so that no vessels might go to sea without a permit

outside in the porch of the church. There was a wild war whoop, and a body of forty or fifty men disguised as Red Indians passed by the door and, encouraged by Adams and the other leaders, went down to the wharf and posted guards all round to prevent the intrusion of spies.

They took possession of the three tea ships, brought up the chests, broke them open and poured the tea into the harbour. In about three hours 340 chests had thus been emptied into the water. No other property was damaged, and the whole business was carried out systematically. Then the "Mohawks" went away, and the town of Boston became as still and calm as if it had been a Sunday. But the rebellion against the English supremacy had begun.

It was not a wild riot in the ordinary sense, for everything was done decently and in order, and no single member of the crews suffered violence. But when daylight dawned it was seen that the harbour was black with floating tea, and everyone knew that the first blow had been struck in what might be a great war.

During the night the news had been carried to the villages all round, and the next day Samuel Adams and four others drew up a declaration of what had been done, and sent the message to New York and Philadelphia by the hand of Paul Revere. The ride has been commemorated by Longfellow in his poem which begins:

> Listen, my children, and you shall hear
> Of the midnight ride of Paul Revere,

and continues thus:

> So through the night rode Paul Revere;
> And so through the night went his cry of alarm
> To every Middlesex village and farm,
> A cry of defiance and not of fear.

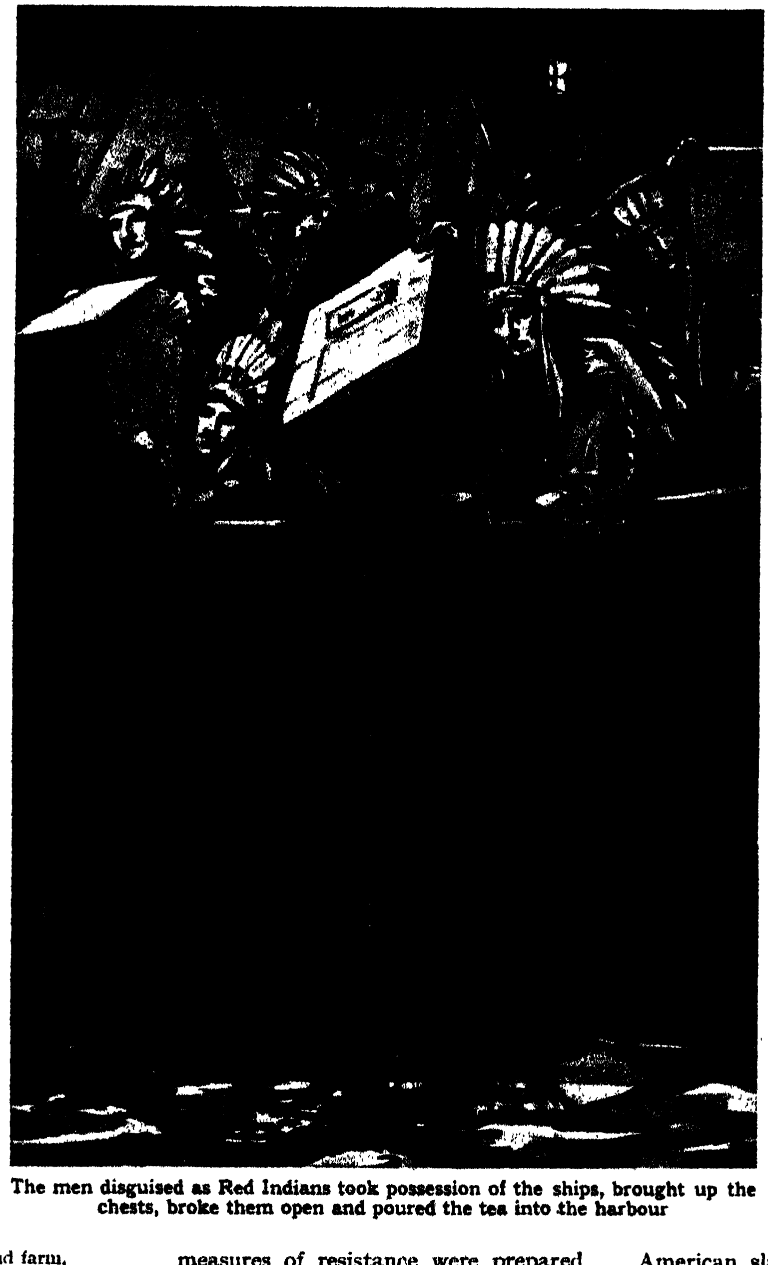
The great "Boston Tea Party," as the act of riot came to be called, had the effect of uniting all the Colonists. As the American historian, George Bancroft, has said, "old jealousies were removed and perfect harmony subsisted between all."

Of course, the Boston riot caused great indignation in England, and the charter of Massachusetts was cancelled. This meant that the Massachusetts Assembly became a rebel government.

The English Governor in Boston began to fortify the place against possible attack by rebels. Then a congress of all the Colonies, except Georgia, was held at Philadelphia, when measures of resistance were prepared and a Declaration of Rights issued. There were men of goodwill on both sides who wanted to bring about a reconciliation, among them the famous Earl of Chatham and Benjamin Franklin, the great American, who was at that time living in England as an agent of certain Colonies.

Matters, however, had gone too far. In Massachusetts the citizens were drilled, and when an English force tried to seize a store of munitions it was attacked by the Americans at Lexington. The War of American Independence had begun.

It was, of course, really a civil war, for while in Britain there were large numbers who sympathised with the American Colonists, in America there were thousands of loyalists. Over 20,000 fought on the English side during the war that followed, and when it was over, 60,000 loyalists left their homes so as to remain under the British flag.



The men disguised as Red Indians took possession of the ships, brought up the chests, broke them open and poured the tea into the harbour

The war dragged on for over six years. At first all the advantage was on the side of the English, and there is no doubt that the Americans would have been defeated had it not been for three things: the skill and determination of George Washington, who commanded the American forces, the incompetence of some of the English generals, and the fact that almost the whole of the rest of the world were unfriendly to England.

At last, in 1782, Great Britain recognised the independence of the thirteen Colonies, and the United States of America was born.

Of course, when we read to-day the Declaration of Independence with its fine-sounding phrases, declaring "We hold these truths to be self-evident, that all men are created equal, that they are endowed by their Creator with certain unalienable Rights, that among these are life, liberty and the pursuit of happiness," we smile at the effrontery or blindness of men who, while publishing such words to the world, could hold in servitude tens of thousands of negro slaves.

American slavery, which lasted till its abolition by Abraham Lincoln on New Year's Day, 1863, was perhaps the most detestable form of slavery that has ever existed at any period. And yet presumably the majority of the citizens who professed to be such upholders of liberty could not see the inconsistency and hypocrisy of their behaviour.